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Combination of Didactic Lecture with Problem Based Learning Sessions in Anatomy

Vaishali V. Inamdar*, Gourav Dadarao Thakre**

Abstract

Anatomy is a highly dynamic science. It is based on factual knowledge and functional correlation and thinking. For centuries it has been regarded as one of the recognized basic biomedical science. In the traditional method of medical curriculum, anatomy is taught in the first year of the course and involves little interdisciplinary interaction. Anatomy is an important basic science that if deficient in, the student may feel inadequately prepared for clinical courses thus, pinpointing the best teaching method warrants investigation. In recent years many researchers worked on Problem Based learning and found that PBL inculcates better understanding, self-directed learning and analytical skills in students [1]. Also it develops problem solving attitude and analytical skills in students. If PBL is included in the curriculum of basic sciences like Physiology, it can help students to apply knowledge of anatomy in clinical practice [2]. However, recently, most of the medical colleges of other countries have adopted a student-centered, problem-based, integrated, community-based, elective-oriented, systematic (SPICES) medical curriculum [3]. So an attempt was made to combine didactic lecture with problem based learning & observe it's effect as a teaching module in anatomy.

Keywords: Didactic Lecture; Problem-Based-Learning; SPICES; Anatomy.

Introduction

Anatomy teaching is an essential part of medical education. It faces tremendous Criticism regarding curriculum design, methods of implementation, and application of knowledge in clinical practice. In the traditional method of medical education, anatomy is taught in the first year and involves little interdisciplinary interaction. Many medical colleges in other countries are teaching along the lines of the student-centered, problem-based, integrated, community-based, elective-oriented, and systematic (SPICES) medical curriculum. For a particular topic, objectives are clearly defined and priority content areas are identified. Overviews given in a didactic lecture class to the entire batch of 100 students. Tutorial classes are conducted thereafter with smaller groups of students (25/batch) divided further into five subgroups of five students each. In these sessions, a problem is presented to the students as a focus for learning or as an example of what has just been taught. Each problem was accompanied with relevant questions to streamline the students' thought processes. A tutor is present throughout the session not as an instructor but as a facilitator of the learning process. A questionnaire sought students' opinion on the usefulness of this approach, relevance of the combination of problem-based learning (PBL) sessions and didactic lectures in understanding a particular topic and relating clinical conditions to basic mechanisms. The majority of the students opined that the combination of didactic lectures and PBL sessions was definitely beneficial regarding all the above-mentioned aspects of learning. Thus it may be considered that a judicious mixture of didactic lectures and PBL sessions is beneficial as a teaching module

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of anatomy in medical colleges.

Problem Based Learning

Problem based learning (PBL) has been defined as an educational method which uses carefully constructed clinical problems as a context for students to learn problem solving skills and acquire knowledge about the basic and clinical sciences [4]. McMaster University, pioneers in the problem based learning (PBL) approach, describes PBL as "a pedagogical approach, which uses cases, and problems as the starting point for acquiring the desired learning objectives" [5]. PBL is also stated to be an educational format that is centered on the discussion and learning that emanates from a clinically based problem [6]. It involves the use of clinical problems to motivate students to identify and apply research concepts and information to realistic situations, work collaboratively, and communicate effectively [7]. PBL is student-centered, encouraging students to become more thoughtful problem-solvers. It promotes life-long habits of active learning: the most effective technique for learning, applying, integrating, and retaining information. It is now a well-established method of facilitating basic science education intended for clinical application [8]. Overall, it can be said to promote self-directed learning. Traditional medical curricula which stresses on conservative lecturing and memory based learning, is passé. From its uncertain beginnings around 40 years as a novel teaching strategy in a few established medical schools worldwide, PBL has become relatively mainstream, though not in India.

History

The idea of problem based learning came from Case Western Reserve University in the mid 1950s [9-11]. It was disseminated due to the work of Harold Barrows, a professor at McMaster University, Canada, over the late 1960s.(12-14) In 1974, The Maastricht University became the first in Europe to integrate PBL into course work. At the turn of the 20th century, nearly 150 medical schools worldwide (around 10% of the total number present) had integrated problem-based learning into their curricula [15].

Process

PBL places emphasis not only on the content of what is to be learned, but also the learning process [16]. There are some essential components of PBL which are as follows [17-21]:

(i) There is a *problem* which acts as a "trigger" for the session

(ii) *Participants* (students) have discussions in *small groups* for a period of time.

(iii) A *tutor* guides the learning process, which occurs through PBL sessions.

(iv) *Lectures* are reduced and only form a part the curriculum.

(v) *Self-initiated* learning is encouraged.

(vi) *Self-study* is a crucial part of the process.

The Maastricht University formulated the "seven jump" sequence which is a chief method to execute PBL sessions. The steps in this sequence are as follows:

1. Clarify and agree working definitions and unclear terms and concepts.
2. Define the problems; agree which phenomena need explanation.
3. Analyze the problem (brainstorm)
4. Arrange possible explanations and working hypotheses
5. Generate and prioritize learning objectives
6. Research the learning objectives
7. Report back, synthesize explanations, and apply newly acquired information to the problem [17-21].

An important aspect of the PBL is teaching basic sciences in the context of a clinical problem, whether real or hypothetical. This serves two goals: to make knowledge more relevant and retrievable, and to foster the development of specific reasoning [22].

In PBL, learners come across a problem and make an effort to solve it with information they already possess allowing them to understand what they already know. They also identify what they need to learn to better appreciate the problem and how to resolve it.

Once they have worked with the problem as far as possible and identified what they need to learn, the learners engage in self-directed study to research the information needed finding and using a variety of information resources (books, journals, reports, online information, and a variety of people with appropriate areas of expertise). In this way learning is personalized to the needs and learning styles of the individual.

The learners then return to the problem and apply what they learned to their work with the problem in order to more fully understand and resolve the problem. After they have finished their problem work

the learners assess themselves and each other to develop skills in self assessment and the constructive assessment of peers. Self-assessment is a skill essential to effective independent learning. The responsibility of the teacher in PBL is to provide the educational materials and guidance that facilitate learning. The principle role of the teacher in PBL is that of a facilitator or educational coach (often referred to in jargon of PBL as a "tutor") guiding the learners in the PBL process. As learners become more proficient in the PBL learning process the tutor becomes less active.

Objectives of PBL

1. Develop an ability to identify relevant health problems that warrant further discussion or self study within the context of a clinical scenario present as a "patient problem"
2. Develop an appreciation for the interrelated nature of the physical, biological and behavioral mechanisms that must be considered with each health problem during the process of generating a management plan.
3. Develop the knowledge base necessary to define and manage the health problems of patients, including the physical, emotional and social aspects, within the context of effective health care provision within the society.
4. Reinforce the development of an effective clinical reasoning process including the skills of problem synthesis, hypothesis generation, critical appraisal of available information, data analysis and decision making.
5. Cultivate the skills necessary to become self directed as a learner, acknowledging personal educational needs and those of group members, and making effective use of available learning resources.
6. Function effectively as an active participant within a small group engaged in learning and the provision of health care.
7. Recognize, develop and maintain the personal characteristics and attitudes necessary for a career in the health professions including the following:

- Awareness of personal assets, limitations and emotional reactions.
- Responsibility and dependability.
- Ability to relate to, and show concern for other individuals and
- The evaluation of personal progress that of other group members and the group processes itself.

Aims & Objectives

1. The aim of the present study was to try and evolve systems of teaching and learning so that the students could adopt a problem-solving approach by applying the concepts and principles of anatomy to clinical problems [23].

2. It was also aimed at finding out whether a judicious mixture of the didactic lectures and problem-based learning (PBL) sessions would be a better option for making the students understand the anatomical concepts related to clinical cases.

Methodology

This study was performed on the batch of first year students, who were studying the endocrine system gross anatomy, microanatomy & embryology at the time the study was being performed. The entire batch consisted of 100 students from different states. First, didactic lectures on a particular topic were taken. The batch was then divided into smaller groups of 25 each, and tutorial classes were conducted for them. Each small group of 25 came to the class 1 day every week. Every day that these 25 students turned up, they were further subdivided into five groups of five students each. There were absentees, but they were not regular absentees, so they underwent the same training in class at some point. Each batch was given a clinical problem in which the symptoms of a particular endocrinological disorder were made very clear, and some questions were given following the said problem. This was done to ensure that students who had just entered medical college will think in an organized fashion. The problems were brief, correctly formulated, and framed in such a way that they matched the students' level of previously acquired knowledge [24,25]. One such clinical problem was given; students were given enough time to study the particular problem with reference to the accompanying questions. They discussed among themselves and followed the basic textbooks of anatomy, physiology and biochemistry and some books of clinical medicine depending on what was the case given. They finally arrived at some conclusion regarding the answers to the questions. A tutor was present throughout the class. He went around from table to table to each of the five subgroups and facilitated the learning process of each student [26]. The tutor did not instruct as to how to solve the questions or where in the book they will find the relevant answers. He just streamlined the thought processes of the students by discussing the answers to which the students have arrived and clarifying if

there is any controversy regarding a question.

There was the possibility of some students hiding and not participating in the program. But because the batch of 25 was further subdivided, it was easy for the tutor to keep an eye on almost all of them and force them to work. Despite this effort, 1–3% still hid, and these were the students who stated that the PBL sessions were not useful.

After the tutorial classes on the whole of the endocrine system were over, the students were given a questionnaire about their opinions.

Observations & Results

Questionnaire (Appendix)

The questions were framed in such a way that yielded responses regarding

- usefulness of didactic lectures, PBL in anatomy tutorial classes, and a judicious mixture of both in the context of understanding the system they are currently studying (Table 1).

Table 1: Response of students regarding the usefulness of didactic lectures, PBL in the anatomy tutorial classes, and a judicious mixture of both in the context of understanding the system they are currently studying. Responses of the in relation to question number 1, 2 & 10 are taken into consideration

	Very Useful	Useful	Not Useful
Didactic lecture	34%	58%	08%
PBL (anatomy tutorial)	51%	45%	04%
Didactic lecture + PBL (anatomy tutorial)	80%	13%	07%

Table 2: Response of students regarding the relevance of PBL in the anatomy tutorial classes and a mixture of didactic lecture and tutorial in the context of relating the clinical condition to the basic mechanism. Responses of the in relation to question number 3,6,7,8 & 9 are taken into consideration

	Yes	No	To some extent
PBL (anatomy tutorial)	75%	01%	24%
Didactic lecture + PBL (anatomy tutorial)	80%	07%	13%

Table 3: Response of whether students had valuable exchange of ideas in small-group discussions in the anatomy tutorial classes and whether this would help them to perform better on the university examinations. Responses of the in relation to question number 4,5,11, & 12 are taken into consideration

	Yes	No	To some extent
Exchange of ideas	61%	04%	35%
Better performance in university examinations	66%	03%	31%

- Relevance of PBL in anatomy tutorial classes and didactic lecture + anatomy tutorial classes in the context of relating the clinical condition to the basic mechanism (Table 2)
- Whether there had been valuable exchange of idea in small-group discussions in the tutorial classes and whether this would improve their performance in the university examination (Table 3).

Discussion

Anatomy has historically been a cornerstone in medical education regardless of nation, racial background, or medical school system. By learning gross anatomy, medical students get a first "impression" about the structure of the human body which is the basis for understanding pathologic and clinical problems. Although the importance of teaching anatomy to both undergraduate and postgraduate students remains undisputed, there is currently a relevant debate concerning methods of anatomy teaching. In the past century, dissection and lectures were its sole pedagogy worldwide. Recently, the time allocated for anatomy teaching was dramatically reduced to such an extent that some suggest that it has fallen below an adequate standard. Traditional anatomy education based on topographical structural anatomy taught in lectures and gross dissection classes has been replaced by a multiple range of study modules, including problem-based learning, plastic models or computer-assisted learning, and curricula integration [27].

Medical Education in India still follows the traditional pattern with efforts by some progressive institutes to pursue newer options. Medical schools in the country have not yet permanently adopted PBL into their syllabi. The Medical Council of India, driven by the observation of a gap between the qualitative and quantitative advancement in medical education and achievements in the field of health care, adopted

the "Regulations on Graduate Medical Education, 1997". It endorses a teaching methodology in which emphasis is placed on encouraging integrated teaching. Traditional teaching is carried out with a PBL approach. There is a reduction in compartmentalization of disciplines so as to achieve both horizontal and vertical integration in various stages. MCI However, it has not released encourages integrated teaching using the PBL approach. Any mandatory guidelines regarding the same.

However, over the majority of the country, PBL is still at a premature stage [28].

Due to unavailability of published data on combination of didactic lecture followed by PBL session on the same topic the results could not be discussed. However according to feedback of the students a didactic lecture followed by PBL session on the same topic helped them to understand the topic more thoroughly motivated them to read more. Students also commented that they could remember the topic better & it helped them to integrate their knowledge.

Eighty percent of the students in the study were of the opinion that a judicious mixture of the didactic lecture and PBL in the anatomy tutorial classes were very useful in understanding the system that they were currently studying. Only 7% felt that this combination was not useful. More than 60% felt that small group discussions led to better exchange of ideas and may help them to perform better in the final examination.

More than 70% of the students opined that the anatomy tutorial classes were helpful in the context of relating the clinical condition to the basic mechanism.

Summary & Conclusion

Anatomy is a distinguished scientific discipline by its emphasis at all levels of organization and its thorough understanding in the study of all the branches of medicine is essential. This study was performed on batch of 100 first year students; a didactic lecture on a particular topic was followed by tutorials on clinical problem on the same topic for which students were divided into smaller groups of 25 each which were further divided into 5 groups of 5 students each. There was a tutor for each subgroup who facilitated the learning process of the students. Then a questionnaire was given to the students & the responses given by the students were analyzed. Eighty percent students opined that judicious mixture of didactic lecture followed by PBL session helped them to understand the clinical problem & the underlying basic mechanism more clearly.

There is no single method of teaching that can ensure thorough understanding of a topic among the students. However, a judicious mixture of didactic lectures and PBL sessions in the tutorial classes may be considered to be important in that it may

- Motivate the students toward self-directed learning.
- Give them a defined objective along the line of which they will be able to have a constructive approach to apply the knowledge of anatomy to various clinical conditions

This will ultimately be beneficial for their entry into the clinical phase and finally patient management.

References

1. Dope SA, Mungal SU, Kulkarni PR. Introducing problem based learning for first MBBS anatomy students. Int J Health Sci Res. 2013; 3(4):50-56.
2. Dr.Mungal Shreechakradhar U, Dr. Santoshkumar A. Dope, Dr. Sushil P. Dube, Dr. N. D. Somwanshi, Dr. S.S. Karadkhedkar, Dr. M. B. Kulkarni. Introduction of Problem Based learning as an innovative T-L method in Physiology at Dr Shankarrao Chavan Govt Medical College, Nanded. IOSR Journal of Dental and Medical sciences. 2013; 9(6):08-12.
3. Harden RM, Snowden S, and Dunn WR. Educational strategies in curriculum development: the SPICES model. Med Educ. 1984; 18:284–297.
4. S. Johnson, P. Finucane. The emergence of problem-based learning in medical education. Journal of Evaluation in Clinical Practice, 6(3):281-91.
5. E.M. PijlZeiber. History, Philosophy and Criticisms of Problem Based Learning in Adult Education, PBL in Adult Education.
6. B. Nanda, S. Manjunatha. Indian medical students' perspectives on problem-based learning experiences in the undergraduate curriculum: One size does not fit all. J Educ Eval Health Prof. 2013; 10:11-2.
7. Shrivastava SR, Shrivastava PS, Ramasamy J. Problembased learning in undergraduate medical curriculum: An Indian perspective. Arch Med Health Sci. 2013; 1:200-1.
8. N. Bhattacharya, N. Shankar, F. Khaliq, C.S. Rajesh, O.P. Tandon. Introducing problem-based learning in physiology in the conventional medical curriculum. The National Medical Journal of India 2011;18:122-31.
9. Baker, C.M. Problem based learning for nursing:

integrating lessons from other disciplines with nursing experiences. Journal of Professional Nursing 2000; 16:258 66.

10. O'Kelly, J., Monahan, R., Gibson, J.P., and Brown, S. Enhancing skills transfer through problem based learning. Department of Computer Science, Technical Report Series, National University of Ireland Maynooth 2000.
11. Savery, J.R., and Duffy, T.M. Problem based learning: an instructional model and its constructivist framework. In B. Wilson (Ed.), Constructivist Learning Environments: Case Studies in Instructional Design 1996.p.135 148. Englewood Cliff, NJ: Educational Technology Publications.
12. Rideout, E. Transforming Nursing Education Through Problem Based Learning. Toronto: Jones and Bartlett Publishers.
13. Savin Baden, M. Problem Based Learning in Higher Education: Untold Stories. Philadelphia: Society for Research into Higher Education & Open University Press.
14. Tanner, J. Problem based learning: an opportunity for theatre nurse education. British Journal of Theatre Nursing. 2003; 9:531 36.
15. J. Spencer, R.L. Jordan. Learner centered approaches in medical education. BMJ. 1999; 123:534-6.
16. Barrows HS.Problem-based, self-directed learning. JAMA. 1983; 250: 3077-80.
17. Barrows HS. How to Design a Problem-Based Curriculum for the Preclinical Years. New York, NY: Springer Publishing 1985.
18. Evensen DH, Hmelo CE. Problem-Based Learning: A Research Perspective on Learning Interactions. Mahwah,NJ: Lawrence Erlbaum 2000.
19. Hmelo-Silver CE. Problem-based learning: what and how do students learn? EducPsychol Rev. 2004; 16 (3):235–66.
20. Schmidt HG. Problem-based learning: rationale and description. Med Educ. 1983; 17(1):11–6.
21. Schmidt HG. Foundations of problem-based learning –some explanatory notes. Med Educ 1993; 27(5):422–32.
22. Walton HJ, Mathews MB, editors. Essentials of problem based learning. Med Educ 1989;23:542-58.
23. Barrows HS and Tamblyn RM. Problem Based Learning: An Approach to Medical Education. New York: Springer, 1980.
24. Ostbye T, Fernando MLD, and Robinson M. Introducing problem based learning into a traditional undergraduate medical curriculum. Nat Med J Ind. 1996; 19:231–236.
25. Paul VK. Innovative programmes of medical education. I: case studies. Ind J Pediatr. 1993; 60: 759–768.
26. Kaufman A. Implementing Problem Based Medical Education–Lessons From Successful Innovations. New York: Springer, 1982.p.56–57.
27. Veronica Papa,Mauro Vaccarezza1. Teaching Anatomy in the XXI Century: New Aspects and Pitfalls. The Scientific World Journal 2013;1-5.
28. Asima Banu *et al.*, Problem based learning in Medical education- A review Journal of Educational Research & Medical Teacher. 2014; 2(2):1-5.

Original Article

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Characterization and Dimensions of Human Occipital Condyle

Tale Archana K.*, Fupare Santosh S., Moosa Shajiya S.*****

Abstract

Objective: Understanding the anatomical basis of craniovertebral anomalies is important when carrying out surgery in the region. A lateral approach during craniovertebral surgery requires resection of the occipital condyles.The present work is aimed to study the morphology of the occipital condyles and their facets is important clinically. *Materials and Methods:* The study was performed on 200 occipital condyles of 100 adult human dry skulls of unknown age and sex. The measurements like Distance between basion and anterior and posterior tip of occipital condyle, Distance between opisthion and anterior and posterior tip of occipital condylewere measured. *Results:* Distance between anterior and posterior tip of occipital condyleand basionwere found to be 10.51 and 26.91 mm on the right and 11.43 and 27.85 mm on the left respectively. Distance between anterior and posterior tip of occipital condyle and opisthion were found to be 38.97 and 27.81mm on the right and 39.05, and 26.98 mm on the left respectively. *Conclusion:* The above said parameters of the occipital condyles and its variations should be taken into consideration during posterior and lateral approaches to the craniovertebral junction by neurosurgeons and orthopaedicians.The larger the distance, the free the space for the postero- lateral approach.

Keywords: Occipital Condyle; Foramen Magnum; Surgical Anatomy.

Introduction

The occipital condyles (OC) of the skull are located with the superior articular facets of the atlas vertebra and form an important junction between the cranium and the vertebral column. Its integrity is thus of vital importance for the stability of craniovertebral junction [1].

Craniovertebralbony abnormalities have been recorded since many years inmorphological and clinicoradiological studies [2]. Anomalies of craniovertebraljunction are of interest not only to an anatomist but also to the clinicians because many of these deformities produce clinical symptoms, the occipital bone being the main site for these variations. Abnormalities of this area can be classified as congenital, developmental, acquired and traumatic, either alone or in combination [3].

During the last two decades, craniovertebral junction has been a focus for variety of anatomical and biomechanical studies. Most of these studies throw light upon the morphometric analysis of occipital condyles, while some provide information regarding the different surgical procedures [4]. The occipital condyles represent the cranial portion of the craniocervical junction. Space-occupying lesions ventral to the spinal canal at the level of the foramen magnum can be reached using a ventral or a dorsal approach. The difficulties and a high rate of morbidity associated with ventral approaches necessitate a dorsal approach in such conditions. Partial resection of the occipital condyle during transcondylar surgical procedure is an important step for access to the ventral and ventrolateral foramen magnum [5], A three

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dimensional understanding of the anatomy is crucially important for any kind of surgery in craniovertebral region. Various authors have reported incidence of vertebral artery injury during trans articular screw (occipital screw) placement and during lateral approaches to the foramen magnum. The injury to the artery during surgery can lead to catastrophic intra-operative bleeding and compromise to the blood flow. This can lead to unpredictable neurological deficits which will depend on the adequacy of blood flow from contralateral vertebral artery [6,7].

Hence, the present study of morphometric analysis of occipital condyle has been undertaken. It is hopeful

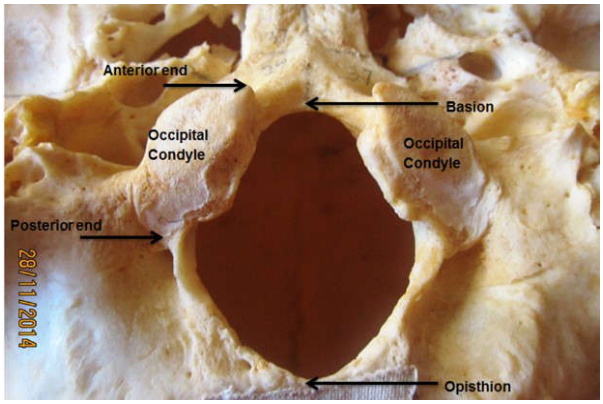

Fig. 1: base of the skull

that the data will be valuable particularly for the neurosurgeon, radiologist and orthopaedician particularly in preoperative decision- making process.

Materials and Methods

The present study was performed on 100 adult human skull of unknown age and sex. All of them were dry and free from deformity and fully ossified.

All the skulls were obtained from Department of Anatomy, Government Medical College. The equipment's used for the purpose of study were

- Vernier calipers,

- Measuring scale - Digital photography equipment

The following parameters were measured on both right and left sides

1. *Distance between basion and anterior tip of occipital condyle:* With the help of vernier calliper maximum distance was noted by anterior margin of midpoint of foramen magnum (Basion) to anterior tip of right occipital condyle and left occipital condyle (Figure 2).
2. *Distance between basion and posterior tip of occipital condyle:* With the help of vernier calliper maximum distance was noted by anterior margin of midpoint of foramen magnum (Basion) to posterior tip of right occipital condyle and left occipital condyle (Figure 3).
3. *Distance between opisthion and anterior tip of occipital condyle:* With the help of vernier calliper maximum distance was noted by posterior margin of midpoint of foramen magnum (Opisthion) to anterior tip of right occipital condyle and left occipital condyle (Figure 4).

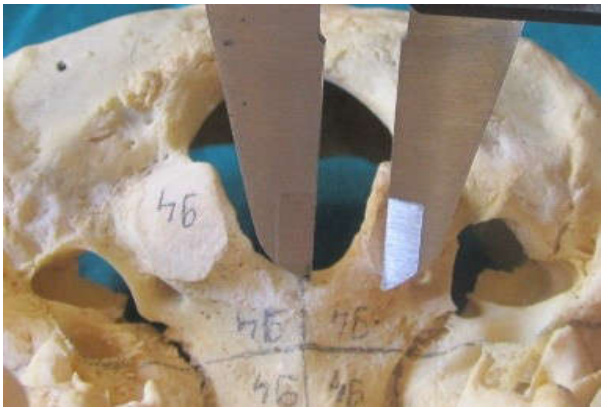

Fig. 2: Showing anterior tip

Fig. 3: Showing posterior tip of occipital condyleand Basion

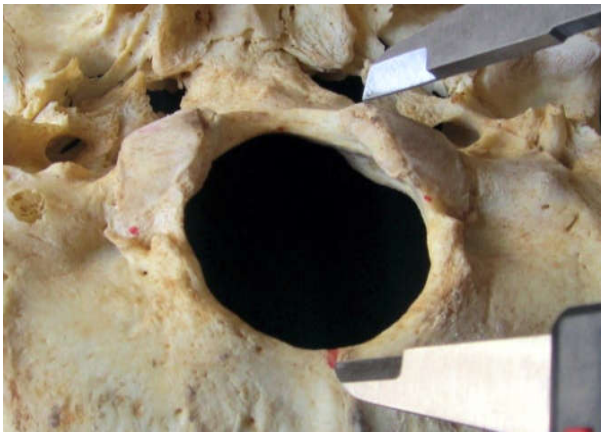

Fig. 4: Showing anterior tip

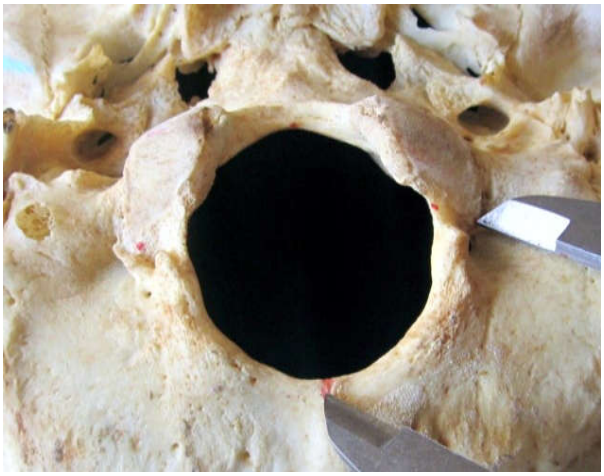

Fig. 5: Showing posterior tip of occipital condyle and Opisthion

4. *Distance between opisthion and posterior tip of occipital condyle:* With the help of vernier calliper maximum distance was noted by posterior margin ofmidpoint of foramen magnum (Opisthion) to posterior tip of right occipital condyle and left occipital condyle (Figure 5).

Results

The results obtained from the present study are shown in Table1. The mean distance between occipital condyle and basionmeasured were found to be 10.51mm (right) and 11.43 mm (left)for the anterior tip, 26.91mm (right) and 27.85 mm (left) for

Table 1: Comparison of Right and Left side of occipital condylar Parameters

S. No.	Parameters	Right		Left		P value	Significance (unpaired't'test)
		Mean	SD	Mean	SD		
1.	Distance between anterior tip of occipital condyle and basion	10.51	2.0	11.43	1.74	0.0001	Significant
2.	Distance between posterior tip of occipital condyle and basion	26.91	3.17	27.85	4.0	0.0011	Not Significant
3.	Distance between anterior tip of occipital condyle and opisthion	38.97	3.44	39.05	3.0	0.7358	Not Significant
4.	Distance between posterior tip of occipital condyle and opisthion	27.81	2.44	26.98	2.48	0.0009	Significant

O.C = occipital condyle, Rt = right, Lt = left, ATOC-B=Anterior tip of occipital condyle and Basion, PTOC-B=Posterior tip of occipital condyle and Basion, ATOC-O=Anterior tip of occipital condyle and Opisthion, PTOC-B=Posterior tip of occipital condyle and Opisthion, S.D = standard deviation.

Table 2: Comparison between others studies

Sr. No	Parameter		Mustafa Bozbugaetal (1999)	Naderi et al. (2004)	Fathy Ahmed (2006)	Avci (2011)	Ozer MA et al (2011)	Ajay Rathva (2014)	Present study
1.	Distance between anterior tip of O.C and basion (ATOC-B)	R	14.4	10.5	11.1	9.9	12.6	10.1	10.51
		L	13.7	11.1	11.3	10.0	10.0	11.0	11.43
2.	Distance between posterior tip of O.Cand basion (PTOC-B)	R	-	27.5	27.38	-	29.4	28.5	26.91
		L	-	28.1	27.97	-	29.5	27.1	27.85
3.	Distance between anterior tip of O.Cand opisthion (ATOC-O)	R	-	38.9	39.9	-	41.4	35.9	38.97
		L	-	39.1	40.1	-	39.7	34.1	39.05
4.	Distance between posterior tip of O.Cand opisthion(PTOC-O)	R	24.3	26.7	27.87	26.6	29.0	26.5	27.81
		L	24.7	26.2	27.94	27.1	30.0	26.1	26.98

O.C = occipital condyle, R = right, L = left ATOC-B=Anterior tip of occipital condyle and Basion, PTOC-B=Posterior tip of occipital condyle and Basion, ATOC-O=Anterior tip of occipital condyle and Opisthion, PTOC-O =Posterior tip of occipital condyle and Opisthion.

the posterior tip and The mean distance between occipital condyle and opisthion measured were found to be 38.97 mm (right) and 39.05mm (left) for the anterior tip, 27.81 mm (right) and 26.98mm (left) for the posterior tip.

There were no significant differences for the measured parameters between the right and left sides.

Discussion

The occipital condyles of the skull articulate with the superior articular facets of the atlas vertebra and form an important junction between the cranium and the vertebral column thus forming the at lanto-occipital joint [8].

Understanding the anatomical basis of craniovertebral anomalies is important whencarrying out surgery in the region. A lateral approachduring craniovertebral surgery requires resection of the occipital condyles. Hence, themorphology of the occipital condyles and theirfacets is important clinically [4].

The surgical treatment for any space-occupyingnlesion is usually performed at the levelof the foramen magnum, through a ventral ordorsal approach [4]. Most of the surgical approaches, suchas the lateral transjugular approach, transtubercular approachandtranscondylar approach, requirere section of the condyles [1,5]. Understandably, surgical resection of theoccipital condyles requires thorough anatomicalknowledge for preoperative planning.

In the present study the mean Distance between anterior tip of O.C and basionwere found to be mean of 10.51±2.0mm on right and 11.43 ±1.74mm on left sides respectively. This measured Distance between ATOC-B comparable to what was found by S. Naderiet al [4]. Who reported the Distance ATOC-B to be 10.5mm on right and 11.1mm on left respectively. Similarly the study carried out by Fathy Ahmed [9] who reported the Distance ATOC-B to be 11.1mm on right and 11.3mm on left respectively.

The mean Distance between posterior tip of O. C and basion was found be to be 26.91±3.17mm on right and 27.85±4.0mmon left sides respectively. This measured Distance betweenPTOC-Bis comparable with the results obtained byFathy Ahmed [9]who reported the OCPT-B as 27.38mm on right and 27.98mm on left. But differ from the results obtained by Naderiet al [4] also reported the PTOC-B as 27.5mm on right and 28.1mm respectively on left side.

The Distance between anterior tip of O.C and opisthion was found to mean of 38.97±3.44mm on right and 39.05±3.0mm on left sides respectively. This measured distance betweenATOC-O is approximate to the result obtained by Naderiet al [4]. Who reported the ATOC-O as 38.9mm on right and 39.1 mm on left sides respectively.

The Distance between Posterior tip of O.C and opisthionwere found to be 27.81± 2.44mm on right and 26.98±2.48mm on left sides respectively. These measured distances are comparable to the results obtained by Naderiet al [4]. Who reported these distances as 26.7mm on right and 26.2mm on left sides respectively and away from the results obtained by Mustafa Bozbuga et al [6] who reported them as 24.3mm on right and 24.7mm on left sidesrespectivelyThe above said parameters will be helpful in interpreting the neurological investigative procedures and also in planning surgical interventions involving the skull base.

Conclusion

In the present study an effort was made to measure various parameters related to occipital condyle. These parameters should be taken into consideration during posterior and lateral approaches to the craniovertebral junction by neurosurgeons and orthopaedicians. Understandably, surgical resection of the occipital condyles requires thorough anatomical knowledge for preoperative planning.

References

1. Al-Mefty O, Borba LA, Aoki N, Angtuaco E, Pait TG. The transcondylar approach to extradural nonneoplastic lesions of thecraniovertebral junction. J Neurosurg 1996; 84:1–6.
2. Vaudeva N, Choudhry R. Precondylar Tubercles on the Basiocciput of Adult Human skulls. J Anat 1996; 188:207-210.
3. Menezes AH: Congenital and acquired abnormalities of craniovertebral junction Youmans Neurological surgery. 5th ed. volume 3. Philodelphia: WB Saunders, 3331-3344.
4. S Naderi, E Korman, G Citak, M Guvencer, C Arman, M S et al. Morphometric analysis of human occipital condyle. ClinNeurolNeurosurg 2005; 107:191-199.
5. Wen TH, Rhoton AL jr., Katsuta, et al. Microsurgical anatomy of the transcondylar, supracondylar and paracondylarextention of the far- lateral approach. J Neurosurg 1997; 87:555-585.
6. Bozbuga M, Ozturk A, Bayraktar B, Ari Z, Sahinoglu

K, Polat G, et al: Surgical anatomy and morphometric analysis of the occipital condyles and foramen magnum. Okajimas Folia AnatJpn 1999; 75:329-334.

7. Abumi K, Takada T, Shono Y, Kaneda K, Fujiya M: Posterior occipitocervical reconstruction using cervical pedicle screws and plate- rod systems. Spine 1999; 24: 1425- 1434.
8. Singh S. Variations of the superior articular facets of atlas vertebrae. J Anat. 1965; 99(Pt 3):565-71.
9. Fatty Ahmed Fetou, Akram M. Awadalla.A morphometric analysis of the occipital condyle and its surgical implication in transcondylar approach. PANS. 2006; 7:124-139.
10. Avic E, Dagtekin A, Ozturk A.H, Kara.E, Ozturk NC, Uluc K et.al. Anatomical variations of the foramen magnum, occipital condyle and jugular tubercle. Turk Neurosurg 2011; 21(2):181-190.
11. Ozer MA, Celik S, Govsa F, Ulusoy MO. Anatomical determination of a safe entry point for occipital screw using three- dimensional landmarks. Eur Spine J. 2011 Sep; 20(9):1510- 17.
12. Ajay Rathva, Dharati M Kubavat, Shaileshkumar K Nagar,Morphometric analysis of occipital condyles with occipitalization of atlas vertebrae. IMJ June 2014;

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A Study of Range of Motion of Temporomandibular Joint in Adult Population of Western Rajasthan

Charu Taneja

Abstract

Introduction: The term goniometry refers to the measurement of angles created at human joints, it may be used to determine both a particular joint position and total amount of motion available at a joint. *Aim & Objectives:* The purpose of the study was to determine the effect of age and gender on movements of temporomandibular joint in 100 normal subjects through the Universal Goniometer. *Material & Methods:* Study was carried out on 100 healthy subjects aged between 20-30 years. All the subjects having normal temporomandibular joint skeleton were chosen and those who were not having any history of joint surgery, trauma or any other type of abnormalities were included for determining the validity and reliability of the goniometric measurements. *Results:* Male subjects showed higher range of motion for depression of mandible, anterior protrusion and lateral deviation than females. *Conclusion:* ROM in all active temporomandibular joint motions except retrusion decreases with increasing age. The males also had a greater mean ROM in right lateral deviation, but the difference between genders was small.

Keywords: Depression of Mandible; Anterior Protrusion; Lateral Deviation; Range of Motion.

Introduction

The term Goniometry refers to the measurement of angles created at human joints, it may be used to determine both a particular joint position and the total amount of motion available at a joint. It is also used to accurately describe abnormal fixed joint positions. Osteokinematic motions are described as taking place in one of three cardinal planes of body (sagittal, frontal and transverse) around three corresponding axes (medial-lateral, Ant-post and vertical) [3].

The temporomandibular joint is a synovial, condylar, and hinge type joint. The temporo-mandibular joint as a whole allows motions in three planes around three axes. The functional motions permitted are mandibular elevation and depression, protrusion and retrusion and lateral deviation.

Range of motion is the amount of motion available at a joint. The starting position for measuring all range of motion (ROM), except rotations in transverse plane is the Anatomical position. Three notation systems have been used to define ROM: the 0 - to 180 - degree system, the 180 - to 0° system and the 360 - degree system. First described by Silver [4] in 1923, its use been supported by many authorities.

The ROM at temporomandibular joint is affected by osteoarthritis, dislocation of mandible, dearrangement of articular disc. The type of motion available at a joint varies according to age, sex and the str. of joint. In the Temporomandibular joint dysfunction, a common disorder that affects more women than men, initially causes hypermobility of the joint but later may cause limitation of motion.

Thus the Determinants of Range of Motion are:-

- Shape of the Bone & cartilage
- Muscle power and tone
- Muscle Bulk
- Ligaments & joint capsule laxity
- Extensibility of the skin & subcutaneous tissue

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- Race (Indians are more mobile than Blacks, who are more mobile than Caucasians)
- Sex (women are mobile than men)
- Age (Range of Motion decreases with age)
- Genetic make up

Day to day stresses on joints.

Aims and Objectives

The purpose of this study is to determine the effect of age and gender on movements of Temporomandibular joint in 100 normal subjects through the ruler.

If in the history the patient has complained that certain loaded or combined movements (those movements giving resistance other than gravity) are painful, the examiner should not hesitate to carefully test these movements is metrically to better ascertain the problem. If a neurological injury is suspected the examiner must carefully assess for muscle weakness to determine the structures injured. If a severe neuropraxia or axonotmesis has occurred, there may be residual weakness even though muscle atrophy is not as evident.

Material and Method

The study has been carried out on 100 healthy subjects aged between 20-30 years. All the subjects having normal temporomandibular joint skeleton and not having any history of joint surgery, trauma or any type of abnormalities were included in this study. The subject's chosen for the study were evaluated and confirmed for the following data:

- They are residents of Rajasthan.
- They have authentic documentation of their date of birth (i.e. birth certificate, driving license, hospitals records etc.)
- *Goniometry:* The physical measurements of temporomandibular joint for determination of range of motion were carried out on same individuals by use of Ruler by us.

For Temporomandibular Joint:-

a. Depression (Lower Jaw inferiorly) - Distance between Upper and Lower central Incisors.

b. Protrusion (Mandibular teeth forwards) - Distance between Upper and Lower central Incisors.

c. Lateral Deviation (Lower Jaw laterally) - Distance between Upper and Lower Cuspids.

The following items are recommended to be included in the recording:

1. Subject's name, age and gender.
2. Date of measurement
3. Type of Goniometer used.
4. Side of the body, joint and motion being measured for example left wrist flexion.
5. Type of motion being measured, that is, passive or active motion.
6. Any subjective information, such as discomfort or pain, which is reported by the subject during the testing.

Recordings should include both the starting and ending positions to define the ROM.

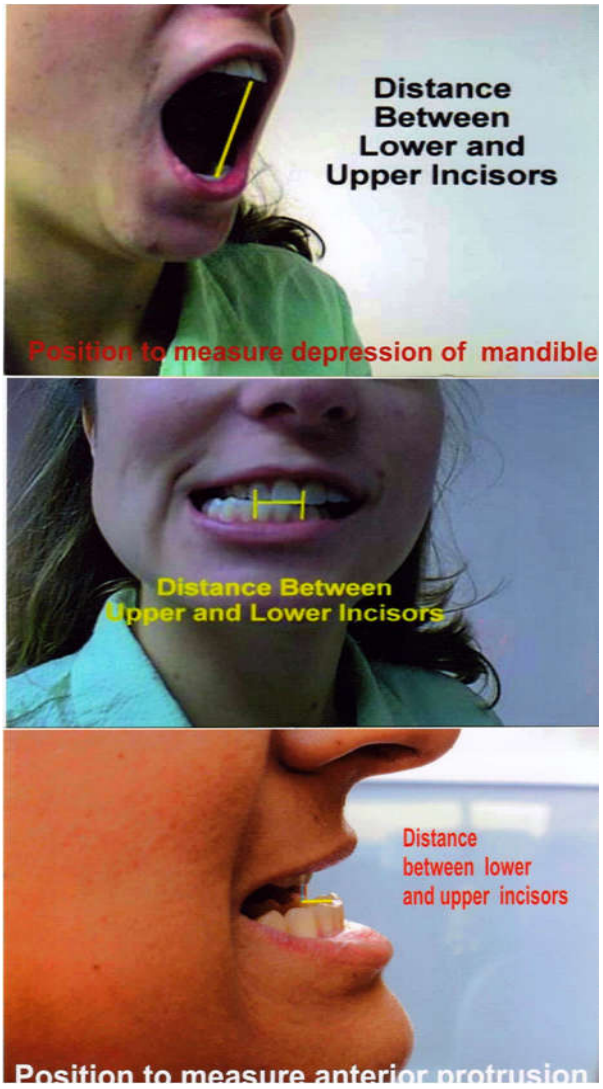

Fig. 1: Showing opening of mouth, lateral deviation and anterior protrusion

Table 1: Showing depression of lower jaw in age group 20-30 years

Sex	Number of subjects	Range (in mm)	Mean (in mm)	SD (in mm)
Male	50	40-55	45.34	4.38
Female	50	35-50	40.46	3.96

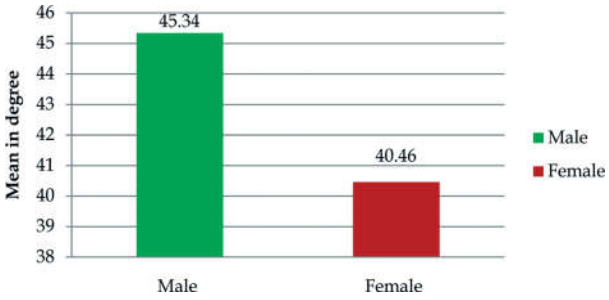

Fig. 1: Shows the relation of depresion of Lower Jaw between male & female (age group 20-30 years)

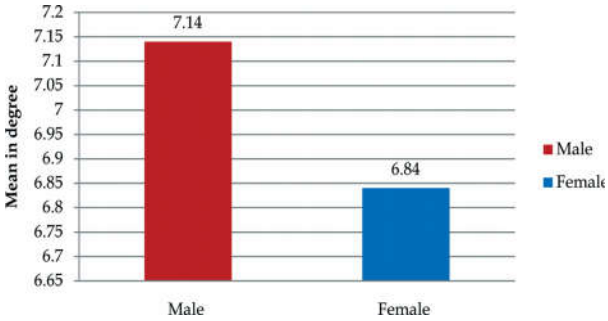

Fig. 2: Shows the relation of Anterior Protrusion of Lower Jaw between male and female (age group 20-30 years)

Table 2: Showing anterior protrusion of lower jaw in age group 20-30 years

Sex	Number of subjects	Range (in mm)	Mean (in mm)	SD (in mm)
Male	50	5-10	7.14	1.44
Female	50	4-9	6.84	1.42

Table 3: Showing lateral deviation of lower jaw in age group 20-30 years

Sex	Number of subjects	Range (in mm)	Mean (in mm)	SD (in mm)
Male	50	5-15	9.84	2.34
Female	50	5-12	9.32	1.99

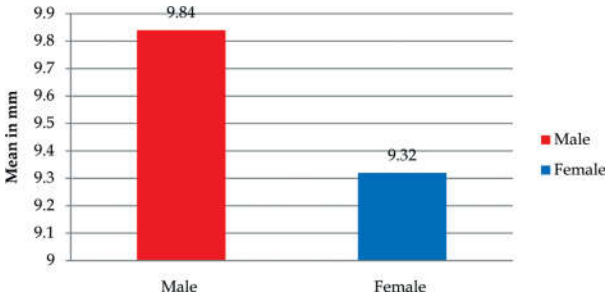

Fig. 3: Shows the relation of Lateral Deviation of Lower Jaw between male and female (age group 20-30 years)

Observations

Showing Measurements of Motion at Temporomandibular Joint (in millimeter) By Plastic Ruler.

Discussion

Coordinated and parallel movements at the temporomandibular joint and cervical spine joints have been observed in some studies and researchers suggest that preprogrammed neural commands may simultaneously activate both jaw and neck muscles. In the temporomandibular disorders popping or clicking noises (or both) in the joint during mouth opening and closing may be present.Other signs and symptoms include facial pain, muscular pain, tenderness in the region of the TMJ, either unilaterally or bilaterally, headaches and stiffness of the neck. Temporomandibular disorders (TMDs), appear to be more prevalent in females of all ages after puberty. The reason for this includes greater stress levels, hormonal influences, and habits of adolescent girls that are extremely harmful to the temporomandibular joints (eg. intensive gum chewing, continuous arm learning, ice crushing, nail biting, jaw play,clenching and bruxism). Seeing the importance of temporomandibular joint great emphasis has been given on studies of various parameters related to temporomandibular joint. The present study has been conducted on 100 subjects (50 male and 50 females) volunteered for Goniometric study and their age group ranged between 20-30 years. Regarding temporomandibular joint the parameters were opening, anterior protrusion and lateral deviation. Range, mean, standard deviation of all the parameters was calculated.

Temporomandibular Joints

Depression of the Mandible: - (Mouth opening)

In the present study the mean values of opening of mouth (Table 1) in age group (20 to 30 years) in males is 45.34 mm ± 4.38 mm and the range is from 40 to 55 mm in males. The mean values of opening of mouth in females are 40.46 mm ± 3.96 mm and the range is from 35-50 mm in females.

Magee (1997) [2] observed that the mandible is able to depress approximately 35 mm to 50 mm so that the subject's three fingers or two knuckles can be placed between the upper and lower central incisor teeth.

Anterior Protrusion

In the present study the mean values of anterior protrusion (Table 2) in age group (20 to 30 years) in males is 7.14 mm ± 1.44 mm and the range is from 5 to 10 mm in males. The mean values of anterior protrusion in females are 6.84 mm ± 1.42 mm and the range is from 4-9 mm in females.

Magee (1997) [2] observed that the movement of anterior protrusion is 3 mm to 6 mm measured from resting to the protruded position.

Walker (2000) [5] studied discriminative validity of temporomandibular joint range of motion measurement and gave Mean ± SD of 7.1± 2.3mm.

Lateral Deviation

In the present study the mean values of lateral deviation (Table 3) in age group (20 to 30 years) in males is 9.84 mm ± 2.34 mm and the range is from 5 to 15 mm in males. The mean values of lateral deviation in females are 9.32 mm ± 1.99 mm and the range is from 5-12 mm in females.

AP Brady, L Mcdevil, JP Stack and D Downey (1993) [1] told that the amount of lateral movement to the right and left sides should be similar, between 10 & 12 mm but may range from 6 mm to 15 mm.

Conclusion

On the basis of present study we can say that the range of motion is affected by various factors such as age, gender, measuring method, type of range of motion (active or passive) and clinically problems.

ROM in all active TMJ motions except retrusion decreases with increasing age. The males also had a greater mean ROM in right lateral deviation, but the difference between genders was small.

References

1. Brady AP,Mcdevil L, Stack JP.Downey D A technique for magnetic resonance imaging of the temporo-mandibular joint.Clin Radiol 1993; 47:127-133.
2. Magee, DJ:Orthopaedic Physical Assessment, ed 2.WB Saunders,Philadelphia 1997.
3. Measurement of joint motion, A guide to goniometry, 2nd edition by Cynthia C. Norkin, Eed, PT 1998.p.1-45.
4. Silver D, measurement of the range of motion in joints. J Bone Joint Surg. 1923; 21:569.
5. Walker N, Bohannon RW, Cameron D: Validity of temporomandibular joint range of motion measurements obtained with a ruler.J.orthop Sports.Phys.ther 2000; 30:484.

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Morphometric Study of Anterior Horn of Lateral Ventricle of Brain and Its Correlation with Age, Gender and Side: A CT Study

Rathod Pranjali U.*, Bhoir Mehera**

Abstract

Background: Ventricular enlargement to be a more sensitive indicator ofcortical atrophy due to increasing age anddementias [1]. The two major changes that may occur in elderly individual without neurologic deficits is enlargement of ventricles and cortical atrophy. Aim of the study was to statistically analyse the length of anterior horn of lateral ventricle in humans and to correlate the changes in relation to age, gender and side. *Method:* The CT images of 150 adult individuals (age group 20-80yrs) was studied in both males and females. Length of anterior horn of lateral ventricle was measured using dicomworks software. *Result:* Mean value of length of the anterior horn increases on both sides as the age increases. Values are larger in 61-80 years.Length of anterior horn ismore in males as compared to females. In relation to the side , the length ofanterior horn is greater on the left side as compared to the right side

Keywords: CT Images; Lateral Ventricle; Cortical Atrophy.

Introduction

Morphometric analysis of cerebral ventricular system is important for evaluating changes due to growth, ageing, intrinsic and extrinsic pathologies. Lateral ventricle size is an index of brain atrophy that can be measured noninvasively using X-ray computed tomography (CT) brain imaging. In crosssectionalstudies of healthy aging, lateral ventricle size increases, whereas memoryand visuospatial performance decrease. Variance of lateral ventricle size alsoincreases with age suggesting substantial interindividual differences in age relatedatrophy [2].

As the human brain ages, characteristic structural changes occur that are considered to be normal and are expected. Thus the thorough knowledge of the age relatednormal changes that occur in the brain is required before any abnormal findings are analysed. Both imaging and autopsy studies have revealed that there is a correlationbetween increase in cerebrospinal fluid spaces and reduction in cerebral volume accompanying normal human ageing [3].

In recent years, Computed Tomography (CT) scan and Magnetic Resonance

Imaging (MRI) have replaced the older methods of studying ventricular system

The size of CSF spaces (ventricles and subarachnoid spaces) increases with age

(Nagata, Basugi, Fukshima et al 1987). Most planimetric studies have demonstrated changes in ventricular size to be greatest beginning after about age 60 years [4].

The ventricular enlargement is present early in the course of schizophrenia and there is evidence that in teenage schizophrenic patients there is a tendency of the enlargement of the anterior horn of the lateral ventricle which may be related with a morphological vulnerability in the prefrontal cortex [5].

Ventricular enlargement reflecting cerebral atrophy has been reported particularly in elderly type 2 diabetes patients. Morphological analysis revealed that the expansion of lateral ventricles in the diabetic brain was prominent in the bilateral frontal horns [6].

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The range of changes in ventricular size of brain encountered in routine clinical practices can mislead most of the physicians and surgeons while making a decision. However, in some conditions precise measurements may be required.

Aim of this morphometric study was to analyse the length of anterior horn and to find its correlation with age, gender and side.

Material and Methods

This was a radiological anatomy study. CT scan images of 150 individuals was studied. CT scan of patients was performed on "Philips Brilliance Slice 64 Multodeteter Spiral Computed Topmography" machine with scanning time of 12-15 seconds and slice thickness of 2mm at the Radiology department of Tertiary Health CareCenters Mumbai. CT scans of patients in the age group of 20-80 years in which the ventricles were reported as normal by radiologist were studied.

CT scan patients with history of local mass lesion, cerebral infarction, hydrocephalus, previous intracranial surgery were excluded from the study.

Data was grouped into threeage group 20-40 years, 41-60 years and 61- 80 years.

Procedure was explained to the patient. Patient was asked to remove metallic items (e.g. earrings, hair pin) and dentures and then positioned on CT table. Patient was placed in a supine position on CT table and was positioned so that therewas no rotation or tilt of midsaggital plane. Measurement were taken on axial section of CT images using Philips Diacom Works Software.

The length of anterior horn was measured on axial CT image passing through cerebral hemisphere showing the anterior horn and the interventricular foramen. Length was measured from the tip of anterior horn uptointerventricular foramen. Section showing maximum length was chosen for measurement.

Results

Table 1: Comparison of the length of anterior horn (mm) on right side in different age groups

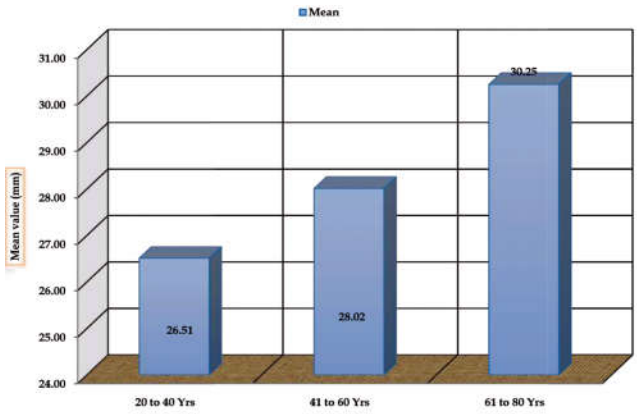
Length of ant horn(mm) on right side	N	Mean	SD	Median	IQR	One way ANOVA test	
20 to 40 Yrs	52	26.51	1.58	26.50	1.78	F Value	P Value
41 to 60 Yrs	59	28.02	1.57	28.00	1.40	54.549	0.000
61 to 80 Yrs	39	30.25	1.98	30.10	2.70	Diff is sig	

Table 2: Comparison of length of anterior horn (mm) on left side in different age groups

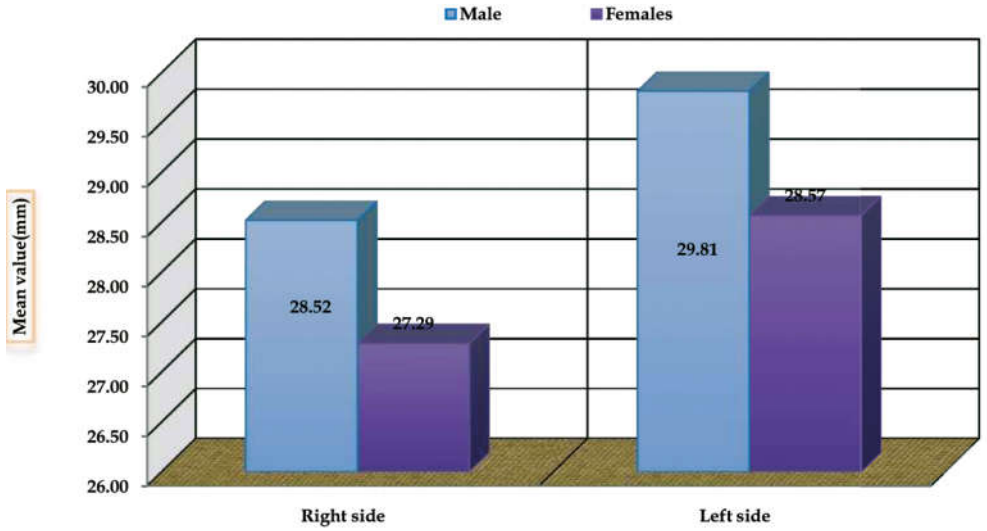
Length of ant horn (mm) on lt side	N	Mean	SD	Median	IQR	Oneway ANOVA test	
20 to 40 Yrs	52	27.62	1.51	27.40	2.28	F Value	P Value
41 to 60 Yrs	59	29.17	1.41	29.20	1.30	81.510	0.000
61 to 80 Yrs	39	31.98	2.02	31.90	2.10	Diff is sig	

Table 3: Comparison of length of anterior horn (mm) in males and females

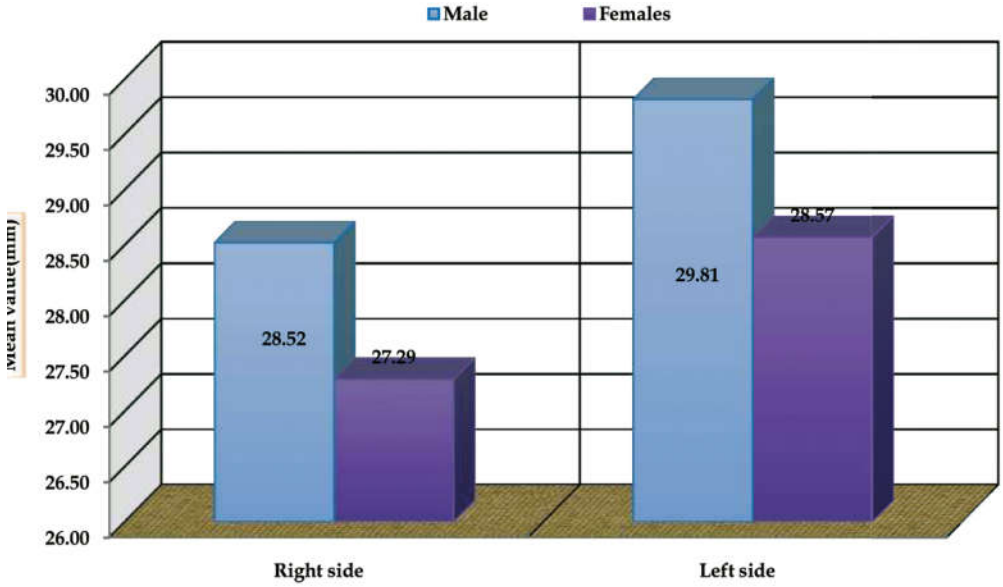
Length of ant horn	Male					Females					Unpaired T	P
	N	Mean	SD	Median	IQR	N	Mean	SD	Median	IQR	Test	Value
Right side	96	28.52	2.26	28.20	2.85	54	27.29	1.91	27.10	2.38	3.383	0.001
Left side	96	29.81	2.41	29.40	2.85	54	28.57	1.99	28.05	2.85	3.227	0.002



Graph 1: Comparison of the length of anterior horn (mm) on right side in different age groups



Graph 2: Comparison of length of anterior horn (mm) on left side in different age groups



Graph 3: Comparison of length of anterior horn (mm) in males and females

Table 4: Comparison of length of anterior horn on right and left side

Parameters (mm)	RT side					Left Side					Unpaired T Test	P Value
	N	Mean	SD	Median	IQR	N	Mean	SD	Median	IQR		
Length of ant horn	150	28.08	2.22	27.90	3.15	150	29.36	2.34	29.25	3.03	4.580	<0.001

Mean length of anterior horn on right side is larger in 61-80years (30.25±1.98).The difference is statisticallysignificant.

Mean length of the anterior horn on left side is larger in 61 – 80 years (31.98±2.02) The difference is statisticallysignificant.

Above Table 1 and 2 suggest that mean value of length of the anterior horn increases on both sides as the age increases. Values are larger in 61-80 years group. Difference is statistically significant.

In the present study the length of anterior horn (mm) in males is 28.52±2.26 and 29.81±2.41 on right and left sides respectively.

In the present study the length of anterior horn (mm) in females is 27.29±1.91 and 28.57±1.99 on right and left side respectively.

The mean length of anterior horn(mm) on right side is 28.08±2.22, on left side it is 29.36±2.34.

Table 3.1: Comparison of length of anterior horn with D'souza study

Parameter	Present Study				D' Souza Study[20]			
	Male		Female		Male		Female	
	Right	Left	Right	Left	Right	Left	Right	Left
Mean length of anterior horn (mm)	28.52	29.81	27.29	28.57	27.4	27.8	25.5	25.8
SD	±2.26	±2.41	±1.91	±1.99	±0.36	±0.37	±0.33	±0.35

Table 3.2: Comparison of length of anterior horn with Brij Raj Singh study

Parameter	Present Study				Brij Raj Singh Study[3]			
	Male		Female		Male		Female	
	Right	Left	Right	Left	Right	Left	Right	Left
Mean length of anterior horn (mm)	28.52	29.81	27.29	28.57	25.00	26.26	25.34	26.53
SD	±2.26	±2.41	±1.91	±1.99	±3.18	±2.94	±3.50	±3.38

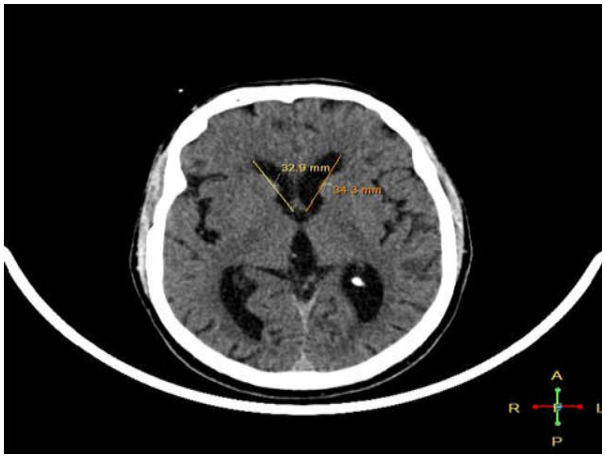


Fig. 1: Length of anterior horn in 60 year male patient

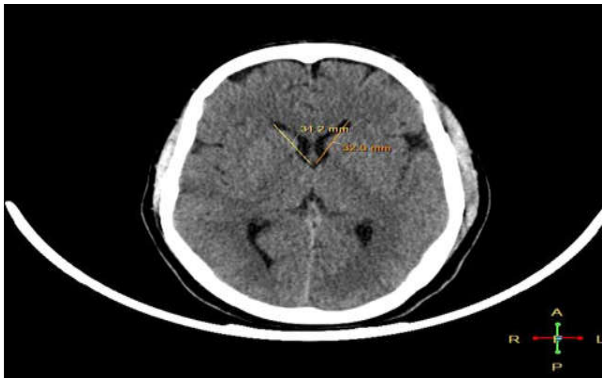


Fig. 2: Length of anterior horn in 60 year female patient

Discussion

The brain grows rapidly in early life and reaches its maximum weight by the third decade; thereafter, regression soon begins. The regression tends to be slow at first, but it accelerates with advancing age, beginning usually by the seventh decade.Regression involves both the cerebrum and the cerebellum [7] .

In literature it has been mentioned that there is great variety and asymmetry in the size of the ventricular system [8]. Counters of the lateral ventricles are relatively constant, except for the occipital horn which may show asymmetry and unilateral or bilateral absence [9].

Variation in the size of the lateral ventricle has been found invarious disorders like Alzheimer's [10], Parkinson's disease [11], schizophrenia [12], anddementia [13].

Before diagnosing abnormal enlargement of the lateral ventricleclinician should know its normal morphometry .

The thorough knowledge of the age related normal changes that occur in the brain is required before any abnormal findings are analysed. As age advances, the brain undergoes many gross and histopathological changes with regression of the brain tissue leading to enlargement of the ventricles [3]. Morphometric changes in the anterior horn of lateral ventricle is seen in teenage schizophrenic patients [5] and type 2 diabetes mellitus patient [6].

To understand these changes the knowledge of normal morphometry and size ofnormalventricular system of the brain is important.

From table no 1and 2 it can be concluded that length of anterior horn increases on both side as the age increases. Values are larger in 60-80 years age group.

Increasing ventricular size with increasing age has been noted by other investigators Roberts MA, Caird F.I. (1976) [14] Hann FJY et al (1976) [15], Barron SA et al (1976) [16], Haug G (1977) [17], Gyldensted C et al (1977) [18], Hughes CP et al (1981) [19]. Our dataalso support the tendency for greater increase in the size of lateral ventricle in theelderly as found by Barron SA et al (1976) [16].

From the present study it can be concluded that the length of anterior horn is more in males as

compared to females. In relation to the side , the length of anterior horn is greater on the left side as compared to the right side.

According to Glydensted C. et al(1977) [18], Takeda and Matsuzawa et al (1985) [21], and D'Souza e Dias Medora C. et al (2007) [20] the left lateral ventricle was larger than the right one and both were larger in males. Present study also found same results for the length of anterior horn is larger in males as compared to females.

In relation to the side , the length of anterior horn is greater on the left side as compared to the right side

Conclusion

Present study has made an attempt to define morphometric measurement of length of anterior horn of lateral ventricle of brain and to find its changes in relation to age, gender and side. This data will be helpful to neurosergons, radiologist and clinician for making the diagnosis.

References

1. Roberts M.A, Caird F.I., Grossart K.W., And Steven J.L. Computerized tomography in the diagnosis of cerebral atrophy. Journal of Neurology, Neurosurgery, and Psychiatry, 1976; 39:909-915.
2. Berardi A., Haxby J.V., De Carli C., and Schapiro M. B.. Face and Word Memory Differences Are Related to Patterns of Right and Left Lateral Ventricle Size in Healthy Ageing Journal of Gerontology . Psychological Sciences 1997; 52(1):54-61.
3. Brij Raj Singh , Gajbe U., Agrawal A, Reddy Y A., Bhartiya S. Ventricles Of Brain: A Morphometric Study By Computerized Tomography. Int J Med Res Health Sci. 2014; 3(2):381-387.
4. Martin l. Albert, Janice E Knoefel Text book of clinical neurology of ageing 2nd edition. Oxford University Press, Inc., 200 Madison Avenue, New York. New York 10016 P no 193.
5. Shiraishi H., Koizumi J.,Ofuku K. Enlargement of the anterior horn of lateral ventricle in schizophrenic patients: Chronological and Morphometrical studies. Jpn J Psychiatry Neurol. 1990 Dec; 44(4): 693-702.
6. Lee JH., Yoon S., Renshaw PF Kim T-S., Jung JJ., et al. Morphometric changes in lateral ventricle of Patients with Recent-Onset Type 2 Diabetes Mellitus. PLoS ONE 2013; 8(4):e60515. doi10.1371/ journal.pone.0060515.
7. LeMay M. Radiologic changes of the ageing brain and skull. AJR Am J Roentgenol. 1984 Aug;143(2): 383-9.
8. Gyldensted C. Measurements of the Normal Ventricular System and Hemispheric Sulci of 100 Adults with Computed Tomography. Neuroradiology 1977; 14:183-192.
9. Usman J. D. Yunusa G. Saidu S. A. Bello A., The Prevalence of the Absence of the Occipital (Posterior) Horns of the Lateral Ventricles among Nigerians (2003 –2008) using Computerised Tomography. International Journal of Health and Medical Information, December 2012; 1(1-3):18-22.
10. Guptha SH, Holroyd E, Campbell G. Progressive lateral ventricular enlargement as a clue to Alzheimer's disease. Lancet. 2002 Jun 8; 359(9322):2040.
11. Lewis MM, Smith AB, Styner M, Gu H, Poole R Asymmetrical lateral ventricular enlargement in Parkinson's disease. Eur J Neurol. 2009 Apr; 16(4):475-81.
12. Malla A.K., Mittal C., Lee M, Computed tomography of the brain morphology of patients with first-episode schizophrenic psychosis J Psychiatry Neurosci 2002; 27(5):350-8.
13. Soininen H., Puranen,M. Riekkinen PJ Computed tomography findings in senile dementia and normal ageing . Journal of Neurology, Neurosurgery, and Psychiatry. 1982; 45:50-54.
14. Roberts MA, Caird FI Computerized tomography and intellectual impairment in the elderly. J Neurol Neurosurg Psychiatry. 1976; 39:986-989.
15. Hahn FJY, Rim K Frontal ventricular dimensions on normal computed tomography. AJR Am J Roentgenol. 1976 Mar; 126(3):593-6.
16. Barron SA, Jacobs L, Kinkel WR. Changes in size of normal lateral ventricles during ageing determined by computerized tomography. Neurology. 1976; Nov; 26(11):1011-3.
17. Haug G. Age and sex Dependence of the Size of Normal Ventricles on Computed Tomography. Neuroradiology. 1977; 14:201-204.
18. Gyldensted C. Measurements of the Normal Ventricular System and Hemispheric Sulci of 100 Adults with Computed Tomography. Neuroradiology. 1977; 14:183-192.
19. Hughes C.P..andGado, M. Computed Tomography and Ageing of the Brain Radiology. 1981 May; 139:391-396.
20. D'Souza e Dias Medora C, Natekar P. E. Morphometric Study Of The Ventricular System Of Brain By Computerised Tomography. J AnatSoc India 2007; 56:19-24.
21. Takeda S. , Matsuzawa T. Age-related change in volumes of the ventricles, cisternae, and sulci: a quantitative study using computed tomography. Journal of the American Geriatrics Society 1985 April; 33(4):264-8.

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Original Article

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Neural Tube Defects with Exencephaly in Human Fetus

Meshram Pritee M.*, Gole Ravikiran*, Hattangdi Shanta S.**

Abstract

Background: Anencephaly and spina bifida are the commonest type of Neural tube defect. Exencephaly is the severe form of anencephaly in whichthere is not only deficiency of scalp and cranial vault but also uncovered immature braintissue protrudes out of the cranium. There isloss of fetal brain tissue to variable degrees and it is considered a precursor to anencephaly . Most cases are stillborn. Present study was carried outtostudy exencephaly and the associated morphological abnormalities. This study also compares the findings with other studies and defines a clinical entity that is incompatible with human life. *Method*: The study was carried out on a collection of 20 aborted fetuses in department of anatomy out of which 11 showed presence of exencephaly. *Result*: These exencephalic fetuses presented with facial abnormalities, cvs abnormalities, skeletal deformities and abdominal abnormalities.This study describes in detail the severe form of NTD called exencephaly and the associated abnormalities. We have described a lesser defined condition that is exencephaly, the anatomical knowledge of such may be important for academic, clinical as well as radiological procedures .With the detailed knowledge of the condition the diagnosis ofexencephaly, can be established sonographically even in the first trimester and necessary measures can be taken.

Keywords: Anencephaly; Exencephaly; Neural Tube Defect; Spina Bifida.

Introduction

The vast majority of congenital anomalies appear during embryonic period of prenatal life. Neural tube defects are the most frequent and devastating congenital anomalies during this period. Neural tube defects are malformations secondary to abnormal neural tube closure that occur between third to fourth week of gestational age [1]. Two types of neural tube defects which are commonly seen are anencephaly and spina bifida. Anencephaly is a congenital absence of a major portion of the brain, skull, and scalp [2]. The primary abnormality is failure of cranial neurulation, the embryologic process that separates the precursors of the forebrain from amniotic fluid [3]. A slightly more severe form of neural tube defect, which is discussed in detail in this article, is exencephaly. In anencephalic fetus, when there is primitive osseous defect of cranial bones the cranial bones are not formed completely and the cranial dome is not closed due to which the brain mass lacks developmental boundaries and protrudes to the exterior through the defect [4]. In this abnormality, prolonged exposure of the developing encephalon to amniotic fluid and repeated mechanical and chemical trauma in utero result in anencephaly[5, 6]. Some studies support the theory that exencephaly is the forerunner of anencephaly[7]. Many imaging studies like the ultrasonography has stated that the Cranial malformations were the most common structural fetal abnormalities in NTDs [8]. Some ultrasonographic studies has described the appearances of exencephaly in the first trimester as the 'Mickey Mouse face'[9,10]. The literature on NTDs is extensive, but few studies provide information on exencephaly and the associated abnormalities. Here we studied exencephaly and the associated abnormalities.

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Aims and Objective

The aim of this study was to describe a rare form of anencephaly that is exencephaly and study its associated anomalies in detail. The study also compared the findings with the other studies to find its clinical significance.

Material and Methods

The study was conducted in Municipal Medical College and general hospital. 20 anencephalic fetus were dissected in the Anatomy department of the institute. The fetal specimens were obtained from department of obstetrics and gynaecology from the same institute. The cases were originated from still birth, spontaneous abortion and therapeutic abortion. No parental history was available. The age was estimated by the criteria like crown rump length, development of limbs and external genitalia. The findings were done by external examination, photography and internal examination. For the internal examination a midline incision was taken on the chest and anterior abdominal wall and the walls were retracted laterally. The presence of exencephaly was recorded and any associated abnormality was studied. The fetuses were observed for the defect in the

a. cranium
b. vertebral column,
c. face and skeletal deformities

Dissection of fetuses was carried out to find out any other internal anomalies cardiovascular system, genitourinary system and abdominal system. Ethics clearance was taken from institutional ethics committee.

Results

In the present study 20 anancephalic fetuses of gestational age 16 to 30 weeks were studied. On external examination it was found that 11 fetuses were exencephalic which showed the recognizable neural tissue found outside the cranial vault (Figures 1, 2). These fetuses ranged in age between gestational age 19 and 30 weeks, and had crown-rump length between 14 and 25 cm whereas in same age group normal fetuses it is found to be 15 to 36 cm [11].

Facial Defects

In 8 fetuses the cranial vault (bony calvarium) is symmetrically absent. All the 11 fetuses showed frog-like appearance with prominent bulging eyeballs, folded ears and absent neck (Figures 1, 2). 6 cases of protruded tongue. 4 fetuses showed cleft lip and cleft palate (Figure 1).

Spina Bifida

Spina bifida was seen in 4 fetuses (Figures 3, 4).Out of the 4 spina bifida, 3 fetuses showed craniorachichisis (Figures 3, 4). The defect in this case was extending beyond the cranial vault (Figure 3). Brain tissue and spinal cord were exposed to the exterior.1 fetus showed spina bifida in lumbar region.

Cardiovascular Defects

When the cardiovascular examination was done 2 cases of VSD (Figure 6) and 3 cases of ASD (Figure 5) was found.

Abdominal and Skeletal Defects

In abdominal examination 1 case each of gastrochisis, omphalocele and umbilical hernia was found. In skeletal system 4 cases of club foot and club hand were found (Figure 7). There was 1 case of kyphosis (Figure 3). In genitourinary examination 1 case of hypospadias was seen.

Fig. 1: Fetus with exencephaly

Fig. 2: Exencephalic Fetus with Cleft palate and cleft lip

Fig. 3: Exencephalic Fetus with craniorachischisis

Fig. 4: ExencephalicFetus with craniorachischisis and kyphosis of thoracic spine

Fig. 5: Cardiovascular defects in ExencephalicFetus showing ASD

Fig. 6: Cardiovascular defects in ExencephalicFetus showing VSD

Fig. 7: Fetus with exencephaly showing clubbed feet and clubbed hand

Discussion

In exencephaly there is a large amount of recognizable neural tissue which is found outside the cranial vault. Facial views reveal frog-like appearance with prominent bulging eyeballs [12]. Chaurasia has given simpler classification of anencephaly based on occipito-vertebral and parieto-occipito-vertebraldefects[13]. Most of the studies suggests that if the defect is limited to the vault then it is classified as anencephaly and when the neural tissue protrudes through the defect it is called as exencephaly[3,4]. Exencephaly is also called as acrania .It has been proposed that the brain tissue of exencephalics may gradually degenerate due to the exposure to amniotic fluid in combination with mechanical trauma. This wearing down of the brain stroma produces the classic anencephalic features with flattened brain remnants behind the prominent orbits [14]. In the present study 11 fetuses out of 20 anancephalic fetuses were exencephalic and all the fetuses showed protruded eyeball, absent neck, folded ears and 6 fetuses showed protruded tongues (Figures 1, 2). Exencephaly can be detected on ultrasound scan at gestational age of 13 to14 weeks [5]. Exencephaly is often associated with rachischisis and other congenital defects [15]. Some animal studies have suggested that exencephaly/anancephaly was associated with malformations of the axial skeleton and spina bifida [16]. In the present study we found 4 cases of spina bifida with 3 case of craniorachischisis (Figures 3, 4) and 1 case of lumbar spina bifida. Also there is 1 case of kyphosis (Figure 3) and also 4 fetuses

showed club foot and clubbed hand. Neural tube defects may also presents with large thymus, small adrenal glands, hypo -plastic lungs, cyclopia, syndactyly, absent radius and thumbs, club foot, imperforate anus, cleft palate, renal and cardiac anomalies. It can also be associated with meningomyelocele, hydrocephalus and Chiari II malformation [17]. In the present study, gastrochisis, umbilical hernia was seen in 1 case each and in another case it was associated with omphalocele. There were 4 cases of cleft lip and cleft palate fig. Major defects of the cardiovascular system occur in 4 to 15 percent of live-born infants with anencephaly [2]. In the present study cardiac abnormalities were seen in 5 cases which were found to be the cases of ASD (3) and VSD (2) (Figures 5, 6).

Conclusion

Neural tube defects may be associated with the unbalanced form of a structural chromosomal abnormality in some families [18,19].Vitamin A deficiency, chromosomal trisomy (Ts12) [20], folate deficiency [21] can induce exencephaly. This study shows that associated morphologic anomalies are very common in fetus with neural tube defects. The study has described in detail the severe form of anencephaly that is exencephaly and the associated malformations. Therefore, considering the increase in incidence of the neural tube defects and the fatal abnormalities associated with it the knowledge of such may be important for academic, surgical as well as radiological procedures and for the accurate diagnosis of the condition. The present study highlights the same and will aid in the early and accurate diagnosis of the condition . The need of the hour is to take preventive measures to reduce the cases of NTDs. If screening and induced abortion are uniformly applied, the incidence of live-born infants with anencephaly would be less [2]. This can be done by interventions such as educational programmes and folic acid supplementation during reproductive age.

References

1. Lauren F, Allen Hauser. Epidemology of Neural Tube Defects. Epilepsia. 2003; 44 (suppl.3):4-13.
2. David A, Stump f, Ronald E, Sherman Elias et al. Infant with anencephaly. New England Journal of Medicine. 1990; 322:669-674.
3. Papp Z, Csecsei K., Toth Z, Polgar K, Szeifert G.T. Exencephaly in human fetuses. Clinical Genetics. 1986; 30:440–4.
4. Toshiyuki H, Emiko U, Chiaki T. Three- and four-dimensional HD live rendering image of fetal acrania/exencephaly in early pregnancy.Journal of Medical Ultrasonics. 2013; 40:271-273.
5. Johnson S.P, Sebire N.J, Snijders R.J.M, Tunkel S, Nikolaides K.H. Ultrasound screening for anencephaly at 10–14 weeks of gestation. Ultrasound Obstetric Gynaecology. 1997; 9:14–16.
6. Campbell S, Johnstone F.D, Holt E.M, May P. Anencephaly: early ultrasonic diagnosis and active management. Lancet. 1972; 21:226–7.
7. Timor-Tritsch H.E, Greenebaum E, Monteagudo A, Baxi L, Exencephaly-anencephaly sequence: proof by ultrasound imaging and amniotic fluid cytology. Journal of Maternal-Fetal and Neonatal Medicine. 1996; 5(4):182–185.
8. Rottem S, Bronshtein M, Thaler I, Brandes J .M. First trimester transvaginal sonographic diagnosis of fetal anomalies. Lancet. 1989; 1:444–5.
9. Nishi T, Nakano R. First trimester diagnosis of exencephaly by transvaginal ultrasonography. Jornal of Ultrasound Medicine. 1994; 13:149–51.
10. Chatzipapas I.K, Whitlow B.J, Economides D.L. The 'Mickey Mouse' sign and the diagnosis of anencephaly in early pregnancy.Ultrasound Obstetric Gynaecology. 1999; 13:196–9.
11. Moore K, Persaud T.V.N. The Developing Human; clinically oriented embryology. 8th Edition, Saunders Elsevier Publication. 2008.p.380-417.
12 Necas M, DuBose T, Taylor V. Exencephaly - Anencephaly Sequence and its Sonographic Features. Obstetrics Gynaecology Ultrasound, Pregnancy and Birth. .2000; Accessed online and available from http://www.obsgyn.net.
13. Chaurasia B.D.Calvarial defect in human anencephaly. Teratology. 1984; 29(2):165-172.
14. Nyberg D.A, Mahony B.S, Pretorius D.H. Diagnostic Ultrasound of Fetal Anomalies: Text and Atlas. Mosby Year Book, St. Louis. 1990.p.149-52.
15. Kulkarni M.L, Mathew M.A, Reddy V. The range of neural tube defects in Southern India. Archives of disease in childhood. 1989; 64(2):201-204.
16. Rengasamy P, Mohamed S.H. Malformations of the axial skeleton in craniorachichisis aperta and exencephaly in rat fetuses induced after neural tube closure.Virchows Archiv A. 1985; 408(1):61-73.
17. Jones K.L. Smith's recognizable patterns of human malformation. 6th Edition; Saunders Elsevier, Philadelphia. 2006; 13:704.
18. Cunningham F.G, Leveno K.J, Bloom S.L, Hauth J.C, Gilstrap L, Wenstrom K.D.Genetics In: Williams's obstetrics. 22nd Edn; Mc Graw-Hill, New York. 2005; pp 285-312.

19. Herbert Thomas, M.D.Family. Prevalence in Anencephaly report Of Case. Journal of the American medical association. 1918; 70(1):10-11.
20. Putz B., Krause G, Garde T. A Comparison between Trisomy 12 and Vitamin A Induced Exencephaly and Associated Malformations in The Mouse Embryo. Virchows Archiv A. 1980; 86:65-80.
21. Smithells R.W, Sheppard S, Schorah C.J,. Folates and the fetus; Lancet. 1977; 1:9-55.

Original Article

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Morphometric Measurement of Anteversion of Femur in South Indian Populations

Roy Tapati*, Nene Ajay R.**

Abstract

Introduction: The measurement of angle of anteversion is important in orthopedic surgery for hip replacement and to gain the normal activities of that joint. It is also important factor to increase the longevity of joint. *Methods:* Adult femora available in the anatomy department of different Medical College in costal Andhra Pradesh including G S L Medical College was used as study sample to get exact idea of femoral anteversion, any significant difference between right and left sided femora in South Indian population and to compare them with previous study. Goniometer and Vernier calliper were used to measure all the parameters. Values were analyzed by using statistical software (SPSS programmed, version-17). *Results:* The anteversion of present study was about 18.78^0. Significant differences between left sided and right sided anteversion was observed. Anteversion on right side is 19.45+/-5.64 and on left side 18.45+/-4.30. The p value is 0.048 which is <0.05. *Conclusion:* The present study is an attempt to evaluate the angle of anteversion among the South Indian Population to determine the bilateral asymmetry and to compare it with the anteversion of other races like Caucasian, Negroes etc as stated in different literatures that might be helpful for orthopedic surgeon in hip replacement therapy.

Keywords: Anteversion; Femoral Neck; Racial Difference.

Introduction

Femur is the longest bone of human body. Neck is rotated laterally in respect of the shaft of femur to form angle of anteversion (according to Gray's anatomy) [1]. The femoral neck anteversion (FNA) is thought to result from medial rotation of the limb bud in intra uterine life [2]. Its value is about $10\text{-}15^0$ although some racial variations are observed in previous study. The value of anteversion also depends upon the axis which has been used for study. Nagar M et al [3] described in his study the value of anteversion in the Indian (i.e. 16.4^0 in males and 15.94^0 in female) is less than African population(19 degree) by using same retrocondylar axis. Farrally et al (1985) reported Indian average anteversion is probably higher than Caucasian and Oriental values but lower than African figures [4]. Hoaqland F.T. [5] reported femora from cadavers of Caucasians, the anteversion angle averaged 7.0^0 in males (range, -2^0 to 35^0) and 10.0^0 in females (range, -2^0 to 25^0) by using transcondylar plane. Using similar techniques on cadavers of Hong Kong Chinese, they found that the average anteversion in males was 14.0^0 (range 4^0 to 36^0) and 16.0^0 in females (range, 7^0 to 28^0). This racial variation of femoral anteversion is an important implication for assessment in correction of anteversion in orthopedic setting in different racial groups. The measurement of angle of anteversion is important in orthopedic surgery for hip replacement and to gain the normal activities of that joint. It is also important factor to increase the longevity of joint.

The present study is an attempt to evaluate the angle of anteversion in South Indian Population to determine the bilateral asymmetry and to compare it with the anteversion of other races like Caucasian,

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Negroes etc as stated in different literatures that might be helpful for orthopedic surgeon in hip replacement therapy.

Materials and Methods

The angle of anteversion can be measured by various methods. For example biplane radiography, CT scan is used to determine anteversion. Clinically FNA is measured by trochanteric prominence angle test (TPAT) or Craig test [6]. The present study is morphological study and the angle of anteversion was measured according to the guidelines given by Nagar M et al [3].

Goniometer and Vernier calliper were used to measure all the parameters to get exact idea regarding anteversion in South Indian population and to determine any significant difference between right and left sided femora in South Indian population. Values were analyzed by using statistical software (SPSS programmed, version-17).

Sample Size and Sampling Design

Adult femora available in the anatomy department of different medical college in costal Andhra Pradesh including G S L medical college was used as study sample. Written permission from the competent authorities was obtained for inclusion of femora from other institutions. All together 220 adult femora were final sample size for the study. Only intact adult femora were taken after the determination of side. Sex determination was excluded from study.

Result Analysis and Observation

Analysis of values shows that out of 220 femora, 110 measurements of each case for right and left sided angles of anteversion give average values (means) as 19.45^0 and 18.11^0 respectively. The mean difference for same parameter between right and left side is 1.35cm [Table 1].

Pair t test were used to determine p and t values for present study. After analyzing, It was found that p values for anteversion is <0.05 which are statistically significant. Value for t and p are -1.99 and 0.048 for anteversion [Table 2].

The angle of anteversion of present study is 18.78 degree (average) while in Asian population showed 14^0 for male and 16^0 for female. The value of anteversion is 7^0 in male and 10^0 in female among Caucasian [Table 3].

Table 1: Measurements of anteversion in dry adult femora

Parameters	Mean	Std. Deviation	Std. Error of mean
Angle of anteversion (degree) n-220	18.78	5.09	0.34
Angle of anteversion of left femora (degree) Number- 110	18.11	4.39	0.42
Angle of anteversion of right femora (degree) Number- 110	19.45	5.64	0.54

Table 2: Statistical comparison of angle of anteversion between right and left side

Variable	Angle of anteversion
Mean+-SD (right side)	19.45+/-5.64
Mean+- SD(left side)	18.11+/-4.39
t-value	1.99
p value(2-tailed level of significance)	0.048
Significance	Significant

Table 3: Comparison between present studies with previous studies of India and outside India

Different Study	Anteversion (Degree)
RC Siwach, S Dahiya	0-36(averrage13.6)
Nagar M et al	Male11.32(left),21.23(right), Female11.02(left),20.87(right)
Caucasian	
Male	7^0
Female	10^0
Asian	
Male	14^0
Female	16^0
Present study(irrespective of sex)	18.78^0

Discussion

The knowledge of the normal proximal geometry is required in selection of patient for prosthesis and pre operative planning of hip replacement and for anthropological studies. Proximal end of femur is also important to design the implants which are suitable for Indian population to give maximum functional end result. The present study was conducted to see the anteversion of femur in South Indian population.

Most of the books of Anatomy quoted an average anteversion angle were about 10-15^0. Not many Indian studies were available with respect to the dimensions of proximal femur. R.C. Siwach [7] (2003) worked on 75 pairs of femora and reported the value of anteversion 13.68^0. Nagar M. et al [3] reported in their study anteversion was about 15.94^0 in female & 16.4 degree in male. P.C. Kinsley et al [8] and Braselio [9] observed in their study average value of anteversion 8.021^0 and 11.32+/-0.3 degree respectively.

The present study was carried out on 220 femora and anteversion of present study was about 18.78^0 . The result of present study almost was similar to Nagar M. et al study but greatly varies from study of P.C. Kinseley [8].

The present study also found significant differences between left sided and right sided anteversion. Anteversion on right side is 19.45+/-5.64 and on left side 18.45+/-4.30. The p value is 0.048 which is <0.05. Similar significant findings were also reported by Nagar M. et al and Octra Braselio [9] in their studies. Greater right side anteversion has been documented by Le Damany [10], Kingsley et al, and Yoshioka et al, [11] in Caucasians, Oriental & African population.

P.C. Kingsley [8] et al reported that retroversion was a frequent finding in adult although in present study no retroversion was observed. Similar findings were reported R.C.Siwach [7] and Nagar M et al [3] in their study.

Conclusion

Femoral anteversion values of South Indian population are almost similar to other regions of India. There are significant statistical differences between right and left sided anteversion. Therefore this study will enlighten orthopedic surgeon and the biomechanical engineer to design the implants suitable for Indian population.

References

1. Roger W. Soams. Skeletal System in: Gray's Anatomy, Churchill livingstones, London 38th Edition; 1996: chapter-6, Page-678.
2. Staheli LT. Medial femoral torsion. Orthop Clin North Am. 1980; 11:39-50.
3. Nagar M, Bharadwaj R, Prakash R. Anteversion in adult femora, Journal of ASI.2000; 49(1):1-6.
4. Farrally, M.R. and Moore, W.J. Anatomical differences in the femur and tibia between Negroids, Caucasians and their effects on locomotion. American Journal of Physical Anthropology.1985; 43:63-70.
5. Hoaglund FT, Low WD. Anatomy of the femoral neck and head, with comparative data from Caucasians and Hongkong chines. Clin Orthop, 1980; 152:10-16.
6. Davids JR, Benfanti P, Blackhurst DW, Allen BL. Assessment of femoral anteversion in children with cerebral palsy: accuracy of the trochanteric prominence angle test. J Pediatr Orthop. 2002; 22: 173-178.
7. Siwach RC, Dahiya S. Anthropometric study of proximal femur geometry and its clinical application. Indian Journal of orthopedics.2003; 37 (4):247 251.
8. Kingsley P.C. and Olsuntead K.L. A study to determine the angle of anteversion of the neck of femur. Journal of Bone and Joint surgery.1948; 30-A: 745-751.
9. Roberto Sergio D. T .C, Giltion S.A.F, Lssejo M, Merandoliono Q.M , Fabiono R.TC, Mario A.B. Femoral neck anteversion: A clinical vs. radiological evaluation. Acta ortop. Bras. 2005; 13(4):171.
10. Le Dammany. Les torsions osseuses leur role dans la transformation des roembres. Jornal of anatomical Physiology.1903; 39:426-450.
11. Yoshioka Y, Siu D. and Cooke T.D.V. The anatomy of functional axis of the femur. Journal of Bone and Joint Surgery.1987; 69:873- 880.


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Accessory Foramina Transversaria in Cervical Vertebrae: Surgico-Clinical Significance

Panchal Padamjeet*, Prasad Bheem*, Singh Shilpa**

Abstract

Introduction: The cervical vertebrae are cranially placed, moveable vertebrae in the human body. The characteristic feature of these vertebrae are the presence of a Foramen Transversarium (FT) in each lateral mass. A plexus of sympathetic nerves surrounding the Vertebral Artery (VA) and Vertebral Veins (VV) passes through the FT. The variable number and size of FT may lead to clinically significant conditions. It may be due to variable course of the VA which implicates an embryological basis. *Aims:* The objective of the present study is to find out the incidence of accessory FT in the cervical vertebrae and its morphological and clinical significance. *Material and Methods:* There were 117 dried cervical vertebrae available in the Department of Anatomy, AII India Institute of Medical Sciences, Patna, Bihar. They were macroscopically studied to find variations in the number of FT. *Results:* Out of 117 cervical vertebrae accessory FT were found in 25 vertebrae (21.3%). The accessory FT were unilateral in 15 vertebrae (12.8%) and bilateral in 10 vertebrae (8.7%). The unilateral foramina were more common than the bilateral one. The accessory FT were smaller and posteriorly placed compared to the regular FT. *Conclusions:* The accessory FT are of importance to radiologists and surgeons operating on the cervical spine.

Keywords: Cervical Vertebrae; Foramina Transversaria; Vertebral Artery; Vertebral Vein.

Introduction

The cervical vertebrae are identified by the presence of a Foramen Transversarium (FT) in each lateral process composed of fused costal elements with its true transverse process. The FT normally transmits second part of Vertebral Artery (VA), Vertebral Veins (VV) and sympathetic fibers from the cervicothoracic ganglion (vertebral nerve) [1]. The seventh cervical vertebrahave smaller FT which transmits only the VV. Sometimes, the vertebral vessels and nervous plexus may get trapped between these two parts, causing formation of accessory FT that may affect the normal course and size of VA [2]. The objective of the present study is to find out the incidence of accessory FT in the cervical vertebrae and its morphological and clinical significance.

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Material and Methods

The study included 117 dried human cervical vertebrae available in Department of Anatomy, AII India Institute of Medical Sciences, Patna, Bihar. Among them there were 69 typical cervical vertebrae and 48 atypical cervical vertebrae. Vertebrae with congenital anomalies and pathological changes were excluded from the study. The vertebrae were macroscopically examined to find out presence of accessory FT. Vertebrae having accessory FT were photographed. The data was compiled and analyzed using Microsoft Excel 2013 software.

Results

Accessory FT were observed in 25 vertebrae. Incidence was calculated to be 21.3%. The accessory FT were unilateral in 15 vertebrae (12.8%), present

mostly on the left side. They were present bilaterally in 10 vertebrae (8.7%). Unilateral FT was more common than the bilateral FT. The accessory foramina were smaller compared to the regular foramina. The accessory foramina were mostly seen in the lower cervical vertebrae (C4, C5, C6 and C7)as shown in Table 1. The maximum number of FT were observed in cervical vertebrae C6. In atypical cervical vertebrae there were five C7 vertebrae showing double FT. All the accessory foramen were posterior to the main FT. One of the vertebrae showing unilateral accessory FT had triple FT on the right side, one accessory foramina was posteriorly placed and the other accessory foramina was posterolaterally placed to the main FT. Incidence being 0.8%.In atlas and axis no accessory FT were found and no vertebra was found with bilateral triple accessory FT. Moreover, no vertebra were found with absence of FT.

Table 1: Incidence of double FT in various cervical vertebrae

Sr. No.	Type of vertebrae	Observed vertebrae	Double FT (U/L)		Double FT (B/L)
			Right	Left	
1	C1	16	0	0	0
2	C2	17	0	0	0
3	C3-C6	69	5	7	7
4	C7	15	0	2	3
5	TOTAL	117	5	9	10

C1: First Cervical vertebrae, C2: Second Cervical vertebrae, C3-C6: Third Cervical vertebrae to sixth cervical vertebrae, FT: Foramen Transversaria, U/L: unilateral, B/L: bilateral.

Table 2: Comparison between the various studies done on the accessory FT

Author(s)	Sample size (No.)	Accessory foramina (%)	Population
Taitz et al, 1978	480	7%	Indian
Nagar, 1999	1388	8.6%	Roman-Bynzatine Jews
Das, 2005	132	1.5%	Indian
Sharma A, 2010	200	8%	Indian
Muralimanju BV, 2011	363	1.6%	Indian
Kaya, 2011	262	22.7%	Jewish
Chaudhary ML, 2013	133	23.15%	Indian
Yadav Y, 2014	120	6.6%	Indian
Gonsai V, 2015	200	20%	Indian
Sangari SK, 2015	71	24%	American
Dofe MY, 2015	60	41%	Indian
Nayak G, 2016	133	6%	Indian
Verma P, 2016	200	8%	Indian
Present study	**117**	**21.3%**	**Indian**

Fig. 1: Typical cervical vertebra showing unilateral double FT

Fig. 2: Typical cervical vertebra showing bilateral double FT.

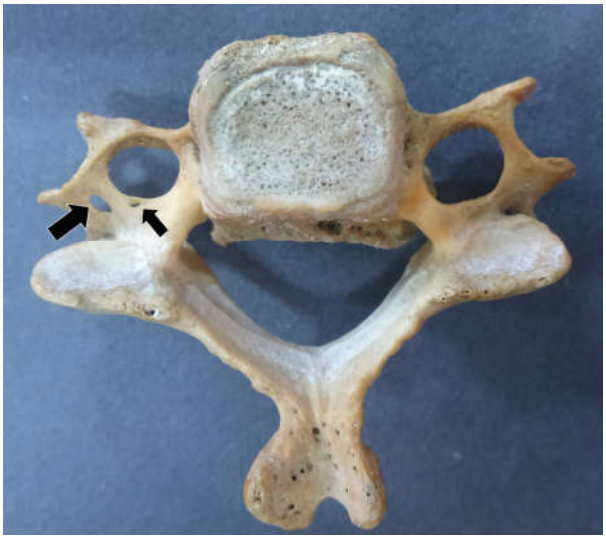

Fig. 3: Typical cervical vertebra (inferioraspect) showing triple FT.

Fig. 5: Atypical cervical vertebra showing bilateral double FT.

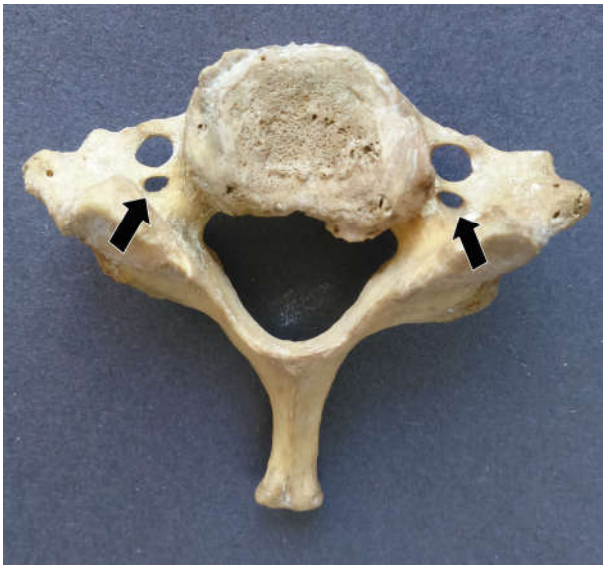

Fig. 4: Atypical cervical vertebra showingunilateral double FT.

Discussion

The VA constitute one of the vascular components of FT of the upper six cervical vertebrae. The VA is developed from the fusion of the longitudinal anastomoses that link the cervical intersegmental arteries which arises from the dorsal aorta. These inter segmental arteries regress except for the seventh intersegmental artery which persists and forms the proximal portion of the subclavian artery which gives rise to the VA [3]. Sim et al described that thepersistence of a portion of the primitive dorsal aorta with two intersegmental arteries may give rise to VA duplication [4]. Taitz et al suggested that the vertebral vessels may be considered as one of the factorsinfluencing the formation of FT. In contrast accessory FT can be useful in evaluating the variant vertebral vessels [2].

The anatomical variation of the FT is also very important to neurologists as the compression of VA may presents clinically with neurological symptoms. These variations can lead to the compression of the VA, particularly during movements of the head leading to vascular insufficiency. This can manifest clinically as headache and fainting attacks [5]. Compression of the VA may lead to hearing disturbances also as it supplies the internal ear as well [6].

In the present study accessory FT were found in 21.3% cases which is comparable to the findings of Kaya et al(2011), Chaudhari ML et al (2013) and Gonsai et al(2015) [7,8,9]. Sangari SK, 2015 examined only the typical cervical vertebrae and reported the presence of double FT in 24% cases of 71 typical cervical vertebrae [10]. Zibis et al (2016) also observed doubleforamina in 14 vertebrae (13.72 %). In seven vertebrae, theduplication was bilateral (6.86 %) [11].

Triple foramen is a very rare variation and seems to be the result of double rib bone element on the same side fusing to theoriginal transverse process [12]. In the present study there was one typical cervical vertebrae with triple FT on the right side (0.8%).Taitz et al found one vertebra with a triple foramen on the left side [2]. Murlimanju et al. found one vertebrae with triplication of FT (0.3%) [13]. Zibiasalso found a triple FT among 102 vertebrae, with an incidence of 0.98% [11].

Duringcervical spine surgeries,while performing posterior cervical procedureswhich may involve instrumentation or screwing in the cervical spine, the VA intactness is highly importantas minor lesions can lead to severe and fatal hemorrhage.

Therefore these findings should be kept in mind during surgical intervention. It is also important to the radiologists for the proper interpretation of X-ray and CT-scan [7].

Conclusion

In the present study 21.3% of cervical vertebrae showed accessory FT. Among them the unilateral accessory FT was more common than the bilateral variety. The accessory foramina were mostly observed in the lower cervical vertebrae. These anatomical variations and morphology of the FT is useful in the operations involving spine surgeries. It is also of great value to the radiologists in the interpretation of X-ray films and CT-scans.

Conflict of Interest

No conflict of interest.

References

1. Susan Standring, Gray's Anatomy, 40th Ed., The anatomical basis of clinical practice, Churchill Livingstone, p.718.
2. Taitz C, Nathan H andArensburg B. Anatomical observation of the foramina transversaria. J. Neurol NeurosurgPsychiatr 1978; 41:170-176.
3. Loneta C andOmojola MF. Angiographic demonstration of bilateral duplication of extra cranial vertebral artery unusal course and review of literature. Am J Neuroradiol. 2006; 27:1304-1306.
4. Sim E, Vaccaro AR, Berzlanovich A, Thaler H and Ullrich CG. Fenestration of the extracranial vertebral artery: Review of the literature. Spine. 2001; 26: 139-142.
5. Caovilla HH, Gananca MM, Munhoz MS and Silva ML.Sindrome Cervical Quadros Clinicos Otoneurologics Mais Comuns. Athenue, Sao Paulo, 2000; 3(11):95-100.
6. Romanov VA, Miller LG andGaevyi MD. The effect of the vertebral nerve on circulation in the inner ear(Cochlea). BiullEkspBiol Med. 1973; 75:10-12.
7. Kaya S, Yilmaz ND, Pusat S, Kural C, Krik A andIzei Y. Double foramen transvsersarium variation in ancient byzantine cervical vertebrae; Preliminary report of anthropological study. Turkish Neurosurgery. 2011; 21(4):1534-1538.
8. Chaudhari ML, Maheria PB and Bachuwar SP. Double foramen transversarium in vervical vertebra: morphology and clinical importance. Indian J Basic Appl Med Res. 2013; 8:1084–1088.
9. Gonsai V, Jadav J and Shah HR. Variations in Transverse Foramina of Cervical Vertebrae: Morphology & Clinical Importance. BJKines-NJBAS 2015; 7(2):6-9.
10. Sangari SK, Dossous P, Heineman T andMtui EP. Dimensions and Anatomical Variants of the Foramen Transversarium of Typical Cervical Vertebrae. Anatomy Research International. 2015; (2015):1-5.
11. Zibis AH, Mitrousias V, Baxevanidou K, Hantes M, Karachalios T andArvanitis D. Anatomical variations of the foramen transversarium in cervical vertebrae: findings, review of the literature, and clinical significance during cervical spine surgery. Eur Spine J. 2016; 25(12):4132-4139.
12. Kimura K, Konishi M, Hu SY. Shape and size of thetransverse foramina in Japanese. OkajimasForia Anat Jpn. 1985; 62:123–132.
13. Murlimanju BV, Prabhu LV, Shilpa K, Rai R, Dhananjaya KVN and Jiji PJ. Accessory transverse foramina in the cervical spine: incidence, embryological basis, morphology and surgical importance. Turk Neurosurg. 2011; 21:384–387.
14. Nagar Y, Taitz C and Reich R. What can we make of these fragments? Excavation at "Mamilla" Cave, Byzantine Period, Jerusalem. Int J Osteoarcheol. 1999; 9:29-38.
15. Das S, Suri R andKapur V. Double Foramina Transversaria: An Osteological Study with Clinical Implications. Int Med J. 2005; 12:311-313.
16. Sharma A, Singh K, Gupta V andSrivastara S. Double foramen transversarium in cervical vertebra an osteological study. J Anat Soc India. 2010; 59:229–231.
17. Yadav Y, Goswami P andBharihoke P. An Osteological study of Foramen Trasversarium: Variations and Clinical Aspects. Journal of Evolution of Medical and Dental Sciences. 2014; 3(68): 14562-14566.
18. Dofe MY, Kasote AP andMeshram MM.The Study of Cervical Vertebrae Showing Variational Presentation of Foramen Transversarium.Int J Anat Res. 2015; 3(2):1128-32.
19. Nayak G, Mohanty BB, Baisakh P, Das SR, Panda SK andChinara PK. Study of Accessory Foramina Transversaria in Cervical Vertebrae and Their Surgical and Morphological Importance.Research Journal of Pharmaceutical, Biological and Chemical Sciences. 2016; 7(3):1370-1373.
20. Verma P, Seema andPiplani M. Study of Incidence of Accessory Foramina in Cervical Vertebrae in North Indian Population. Int J Anat Res. 2016; 4(2):2316-2319.

Original Article

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Learning with Concept Maps versus Classical Lecture and Demonstration Methods in regards to Gross Anatomy of Knee Joint: A Comparison

Mahindra Kumar Anand*, T.C. Singel**

Abstract

Introduction: Higher education like medical education aims not only to prepare students to learn existing knowledge but to generate new knowledge and apply that knowledge to solve complex problems.Research suggests that complex problems can be solved with the help of knowledge integration. The use of conceptmaps as teaching toolfacilitates knowledge integration.Present study was undertaken to sensitize students to use concept maps and to compare learning with concept maps versus with traditional lecture and demonstration methods. *Methods:* A randomized cross sectional prospective study was conducted on 120 medical students of 1st year. Students were divided into 3 groups A, B and C. Group A studied "Gross anatomy of knee joint" by developing concept maps in number of small subgroups. Group C learnt through lecture and demonstration methods. Group B studied with concept maps developed individually by each student. Pre and posttest were conducted for all groups with pre validated questionnaire. Feedback was obtained from both students and faculty through a 5 point Likert scale. Students T test was applied for statistical analysis. *Result:* There was significant improvement in knowledge in group A and B students in comparison to group C students. This improvement was more marked in regards to high cognitive type MCQs. 90% students found that development of concept maps helped them to understand topic better. *Discussion and Conclusion:* Concept mapping is a better teaching learning tool than lecture and demonstration methods. Teaching-learning with development of concept maps individually or collaboratively facilitates higher cognitive learning.

Keywords: Concept Maps; Knee Joint; Knowledge Integration; Meaningful Learning.

Introduction

Lecture is the most common method of teaching-learning in medical education [1]. However, the retention of knowledge and recall from lecture is less than 5% after 6 months [2]. Higher education like medical education aims not only to prepare students to learn existing knowledge, but to generate new knowledge and apply that knowledge to solve complex problems. To make sense of any complex problem requires connecting ideas and eliciting relations between ideas. This sense making refers to the placement of items into frameworks, comprehending, redressing, constructing meaning and patterning [3]. Continuous effort to understand connections of items present in framework [4] allows to solve the complex problem. Research suggests that in order to form an integrated knowledge, learners need to add and distinguish new ideas and connections to their existing repertoire of ideas rather than replace existing ideas [5,6,7].

Knowledge integration describes learning as the process of integrating ideas through the cognitive processes. Knowledge integration [8,9] involves eliciting preexisting concepts, adding new concept,

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connecting new concept with preexisting concept, critiquing, distinguishing concepts, sorting and refining new concepts and lastly applying these concepts in cognitive process.

To facilitate knowledge integration processes, concept maps can serve as tools to elicit relations between ideas within and across contexts. Concept maps can be defined as a form of node-link diagram for organizing and representing semantic relations among ideas [10].

Like other node-link diagrams, concept maps consist of visuo-spatially arranged nodes and links, but additionally they also present semantic information in the form of link labels. A concept map consists of nodes (ideas/concepts), directional linking lines, and linking labels that describe the relation between nodes. Two nodes connected with a labeled line are called a proposition [11].

Bransford, Brown, and Crocking [8] concluded that concept maps can change students' understanding beyond remembering isolated ideas to constructing meaningful connections of organized knowledge. Mason [12] observed that once students are exposed to concept 'mapping' during instructions, they demonstrated insight into the inter-relationship of different concepts instead of just seeing scientific knowledge as a collection of isolated facts.

Ali Saeedi et al [13] compared different methods of presentation and concept map formation. Authors concluded that the best way for use of concept maps is teacher-generated concept maps with texts.When concept maps are generated collaboratively in groups, they become shared social artifacts that elicit existing and missing connections and spur discussion among students and teachers. Both concept maps and collaborative learning have been found to have educational benefits [11].

Present study was undertaken to compare learning with traditional lecture and demonstration methods versus learning with concept maps developed individually and collaboratively. Faculty and students feedback was also collected in regards to utility of concept maps in learning process.

Materials and Methods

A randomized cross sectional prospective study was conducted after taking due permission from IEC and obtaining consent from students. 120 students of 1st year MBBS class of Gujarat Adani Institute of Medical Sciences, participated in the study. Students were randomly distributed in three groups A, B and C. Each group consisted of 40 students. The topic of study was gross anatomy of knee joint.

Group A was exposed to concept mapping and study of specimens of knee joint in dissection laboratory. This group had two sessions of concept mapping. 1st session of one hour on day one was conducted to make them aware about the process of development of concept maps with the help of an example. In 2nd session of three hours, the next day, students were divided into 8 small subgroups of 5 students each. Each group developed its own the concept maps of gross anatomy of knee joint (Figure 1). Students worked in collaboration in each group. Faculty facilitated the process by answering any queries of students without actually aiding the students to form concept map. This was followed by two sessions of dissection laboratory, of two hours each, for them to study the knee joint according to their concept mapping.

Group B was also exposed to concept mapping and study of specimens of knee joint in dissection laboratory same as group A. The only difference was that the students of group B developed concept maps individually.

Group C was exposed to traditional lectures and demonstrations of specimens of knee joint in dissection laboratory. They had three sessions of lectures of one hour each. Each lecture was followed by a session of demonstration of specimens, on 3 consecutive days. They were given 2 hours of dissection laboratory hours for self-study. Three topics, Gross anatomy of knee joint, internal structure and movements of knee joint and applied anatomy of knee joint were covered in the lectures.

Pretest and post-test were given to all students. Pre and post-tests consisted of pre validated 10 single correct answer type MCQs, to test recall and 5 single correct answer case history type MCQs, to test higher cognitive learning. Total marks for both types of MCQs were equal. A questionnaire was given to each group to get the feedback from students. It was in the form of Likert's five point scale, 1. Strongly disagree, 2. Disagree, 3. Neutral, 4. Agree and 5. As Strongly agree. Similar questionnaire was given to faculty to get their feedback.

Statistical analysis was done on the data obtained with the help of Microsoft excel software to find out the median, mode and standard deviation; student t test was applied to find out any significant difference in the marks. Significant p value was taken as <0.05.

Results

Table 1 : Mean marks obtained by students of group A, B and C in pretest and post-test and standard deviation. Comparison of p value of pre and post-test

	Pre test- Maximum Marks=20		Comparison of p value- Pre test	
Group	**Mean marks**	**Standard deviation**	**Group**	**P value**
A	6.42	2.53	A and C	0.6526
B	6.52	2.57	B and C	0.8613
C	6.175	2.41	A and B	0.5323
	Post test - Maximum Marks=20		Comparison of p value- Post test	
A	14.6	2.79	A and C	P < 0.0001
B	12.4	2.42	B and C	P = 0.0003
C	9.8	3.51	A and B	P = 0.0002

Table 2 : Mean marks obtained by students of group A, B and C in questions of pre and post-test meant to test higher cognitive knowledge. Standard deviation is also included in table. Comparisons of p value of the same are given in table

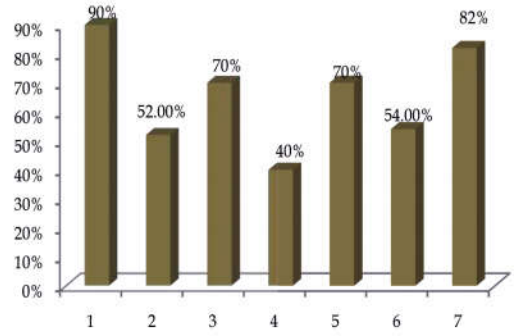
	Pre test- to test higher cognitive knowledge- Maximum Marks=10		Comparison of p value- Pre test	
Group	**Mean marks**	**Standard deviation**	**Group**	**P value**
A	3.55	2.09	A and C	0.8268
B	3.05	2.17	B and C	0.2984
C	3.45	1.97	A and B	0.3912
	Post test - to test higher cognitive knowledge- Maximum Marks=10		Comparison of p value- Post test	
A	8.3	1.91	A and C	P < 0.0001
B	6.45	2.02	B and C	P = 0.0001
C	4.65	2.32	A and B	P = 0.0004

Table 3: Mean marks obtained by students of group A, B and C in questions of pre and posttest meant to test recall knowledge. Standard deviation is also included in table. Comparisons of p value of the same are given in table

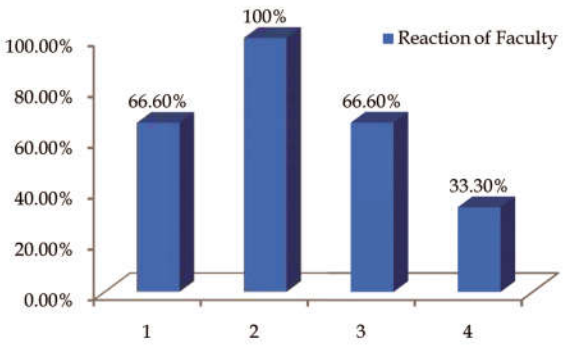
	Pre test- to test recall knowledge- Maximum Marks=10		Comparison of p value- Pre test	
Group	**Mean marks**	**Standard deviation**	**Group**	**P value**
A	2.87	1.38	A and C	0.6465
B	3.47	1.79	B and C	0.0474
C	2.72	1.53	A and B	0.0972
	Post test - to test recall knowledge- Maximum Marks=10		Comparison of p value- Post test	
A	6.3	1.84	A and C	0.0118
B	5.95	1.62	B and C	0.0631
C	5.15	2.14	A and B	0.3693

Table 4: Comparison of obtained mean marks in pre and posttest in the same group

Group	**Comparison of obtained mean marks in pre and posttest to test higher cognitive knowledge (p value)**	**Comparison of obtained mean marks in pre and post to test recall knowledge (p value)**
A	< 0.0001	< 0.0001
B	< 0.0001	< 0.0001
C	= 0.0148	< 0.0001



Graph 1: Percentage of students who responded with >3 score on Likert Scale in response to question 1 to 7 (Table 5)



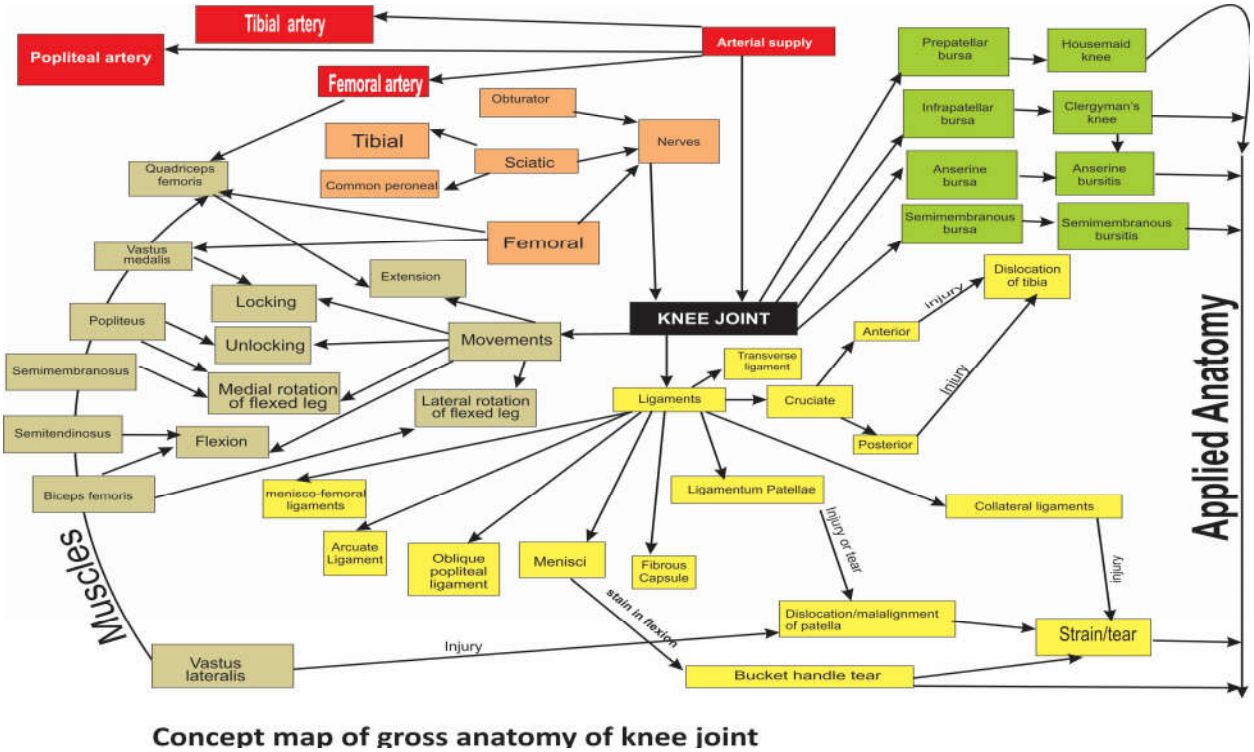
Graph 2: Percentage of Faculty who responded with >3 score on Likert Scale in response to question 1 to 4 (Table 6)

Table 5: Student's reaction obtained on Likert's scale

S. No.	Reaction of Students to following statements on Likert's scale
1	Creating a concept map of gross anatomy of knee joint has helped me to understand the topic better.
2	Lecture and demonstration have helped me to understand the topic better.
3	I developed deeper understanding of the topic with development of each step of the concept map.
4	I developed deeper understanding of topic with lecture and demonstration.
5	I enjoyed the whole process of creating a concept map.
6	Development of concept map takes more time than usual traditional learning.
7	The development of concept map should be included in curriculum.

Table 6: Faculty's reaction obtained on Likert's scale

S. No.	Reaction of Faculty to following statements on Likert's scale
1	Developing concept maps is a better method of teaching learning than lecture and demonstration
2	I enjoyed the whole process of creating a concept map with students.
3	Development of concept map takes more time than usual traditional learning.
4	The development of concept map should be included in curriculum.



Concept map of gross anatomy of knee joint

Fig. 1:

Discussion

The 'gestalt effect' of concept maps allows viewing many ideas at once, increasing the probability of identifying gaps and making new connections. Generating concept maps requires learners to represent ideas in a new form which can pose desirable difficulties [14] - a condition that introduces difficulties for the learner to slow down the rate of learning and enhance the long term learning outcomes, retention and transfer. The process of translating ideas from texts and images to a node-link format may foster deeper reflection about ideas and their connections [15] and prevent rote memorization [16].

Textbooks have fixed sequence or order of presentation. Concept maps have no such fixed sequence or order and may thereby encourage knowledge integration. Adding and revising concept maps require students to decide which ideas and connections to include or modify. Developing such criteria to select ideas require deeper processing of knowledge than the student might normally exercise when reading text. The decision-making process may foster the generation of criteria to distinguish pivotal ideas. Clustering the related ideas in spatial proximity can support learners' reflections on shared properties of and relationships between ideas. Links between ideas from different areas can be seen as indication for knowledge integration across different contexts. Students need to develop meta-cognitive strategies to distinguish alternative ideas [8].

Research suggests that concept mapping is especially efficient, in comparison to other interventions such as outlining or defining ideas, for learning about the relations between ideas [11]. Concept maps as knowledge integration tools elicit ideas as nodes (concepts) and relations between ideas as labeled arrows. The visual format of concept maps can foster criticaldistinctions between alternative ideas and relationships, either individually or through collaboration in communities of learners.

Present study was intended to compare learning with concept maps developed individually and collaboratively in groups versus learning with classical lecture-demonstration methods. Statistically significant difference was found between learning with concept maps, group A and learning with lecture-demonstration methods, group C. The p value was <0.0001 (Table1). Mean marks obtained in post-test by group A were 14.6. Mean marks obtained by group C were 9.8 (Table 1). Hence, results show higher academic performance with use of concept maps as learning tool developed collaboratively than traditional lecture and demonstration methods in gross anatomy of knee joint. Previous studies, by Yavuz Erdoðan [17] on Turkish medical students and by Horton et al [18] in 19 classroom implemented quantitative studies, observed higher academic success with concept mapping in comparison to traditional lecture demonstration methods. Farzane Saeidifard et al [19] carried out a randomized controlled trial on seventy six medical students during sixth year of 7-year MD curriculum clerkship phase. Authors concluded that the concept mapping method may develop meaningful learning among medical students. Sylvia C Vink et al [20] (2015) conducted a study on seven groups of expert clinicians and basic scientists and seven groups of residents with a similar disciplinary composition who constructed concept maps about a clinical problem that fit their specializations. Residents outshone experts as regards learning to articulate integration as comparison of the draft and final versions showed. Constructing concept maps in multidisciplinary groups of three has been found helpful. However, Farida Qadir et al [21] conducted a study on 50 dental students and found no significant difference in marks obtained by the group studied with concept maps versus the group studied with traditional learning methods. Thus, most of the studies have similar results as the present study.

There was a statistically significant difference (p value 0.0002) found between group A and group B (Table 1). Mean marks obtained in post-test by group A were 14.6 and group B were 12.4 (Table 1). This indicates that learning with collaboratively developed concept maps leads to higher knowledge retention in comparison to the learning with concept maps developed individually in gross anatomy. Cañas [11] observed that when concept maps are generated collaboratively in groups, they become shared social artifacts that elicit existing and missing connections and spur discussion among students and teachers. Both concept maps and collaborative learning have been found to have educational benefits [11]. Present study also suggests that learning with collaboratively developed concept maps give better result than learning with concept maps developed individually.

There was statistically significant difference (p value 0.0003) found between group B and group C (Table 4). This signifies that there is positive difference in knowledge retention when learning with individually developed concept maps in comparison to learning with traditional lecture and demonstration methods in gross anatomy. Nesbit and

Adesope [22] conducted a meta-analysis of fifty-five experimental and quasi-experimental studies in which students learned how to use concept maps. They found that the use of concept maps was associated with increased knowledge retention, with mean effect sizes varying from small to large depending on how the concept maps were used. However, Ali Saeedi et al [13] compared different methods of presentation and concept map formation. Total 66 students of 3rd year high school participated in the study. The results of this study indicated that presentation of pre-prepared concept maps significantly improved comprehension, compared to the map generation and control group. Authors concluded that the best way for use of concept maps is teacher-generated concept maps with texts.

Integration of knowledge leads to meaningful learning. Meaningful learning is the part of higher cognitive learning process. In the present study, case history type MCQs were given to test higher cognitive learning. The results indicate statistically significant difference (p value <0.0001) between learning with concept maps developed collaboratively, Group A and learning with lecture-demonstration methods, Group C (Table 2). Mean marks obtained in group A were 8.3 (Table 2) while mean marks obtained by group C were 4.65(Table 2). The above results emphasize that use of concept maps as teaching learning tool developed in a group facilitates higher cognitive learning in comparison to lecture and demonstration methods. This is similar to the findings of Clayton LH [23] and Daley et al [24]. Clayton LH [23] (2006) concluded on review of the current state of the science with regard to concept mapping demonstrated that this teaching-learning method assists nurse educators to prepare graduates to think critically in the complex health care environment.

There was statistically significant difference (p value 0.0004) found between mean marks obtained by group A and group B (Table 2). Mean marks obtained by group B were 6.45 (Table 2). This signifies that learning with concept maps developed collaboratively facilitates higher cognitive learning than learning with concept maps developed individually in gross anatomy.

There was statistically significant difference (p value 0.0001) between mean marks obtained by group B and group C (Table 2). This indicates that there is better higher cognitive learning when learning with concept maps developed individually than learning with lecture and demonstration methods. Other studies e.g. Sarhangi F et al [25] compared the effect of lecture and concept mapping based learning, on cognitive learning in their study on 66 fifth semester nursing students in cardiovascular course. They concluded that concept mapping method is more effective in reaching meaningful learning and high levels of understanding than lecturing method. In other comparative study conducted by Hilda Leonor Gonza´lez et al [26] on 3rd semester medical students on mediated learning experience and concept maps versus traditional teaching learning, they observed that intervention with concept maps promoted meaningful learning that allowed the students to transfer this knowledge to solve problems.

Knowledge retention for simple recall was observed similar in group A in comparison to group B (p value <0.3693) and C (p value 0.0118) (Table 3). Same is true for comparison of Group B and Group C (p value 0.0631) Hence, use traditional lecture and demonstration methods is as good as use of development of concept maps as learning tool for recall knowledge.

A statistically significant difference was found between mean marks obtained in pretest and post-test of group A. The p value for the mean marks obtained to test simple recall was calculated as <0.0001(Table 4). The p value for the mean marks obtained to test higher cognitive knowledge was calculated as <0.0001(Table 4). Therefore, use of concept maps as learning tool facilitates recall and higher cognitive learning both.

In group C, the p values for marks obtained in MCQs to test recall and MCQs to test higher cognitive learning were calculated as <0.0001 and 0.01 respectively in pre and post-tests (Table 4). Hence, one can conclude that traditional lecture and demonstration methods facilitate simple recall knowledge and learning better than higher cognitive learning.

In group B, the p values for marks obtained in MCQs to test recall and MCQs to test higher cognitive learning were calculated as <0.0001 and <0.0001 respectively in pre and post-tests (Table 4). It shows that learning with concept maps facilitate simple recall knowledge as well as higher cognitive learning.

No statistically significant difference was found in mean marks obtained by Group A, B and C in pretest questions to test recall and pretest questions to test higher cognitive learning (Table 1, 2 and 3). This suggests that the initial knowledge base of all students included in study was equal for the given topic.

In a study by Anto´nio B. Rendas et al [27], all 14 students claimed that concept maps provided a useful visualization of the concepts, were a good tool to study and revise the content of each block,

promoted meaningful learning instead of rote learning and could be progressively produced. In the present study, questionnaire was focused to get students reaction on the understanding of the subject topic, time taken to develop concept maps and their opinion to include it in regular teaching learning process (Table 5). Majority (90%) agreed that creating concept maps helped them to understand the topic better and 70% thought that they developed deeper understanding of the topic with development of each step. Most (70%) enjoyed developing concept maps (Graph 1). More than half students (54%) however felt that it is time consuming (Graph 1). 52% found that lecture and demonstrations also developed deeper understanding (Graph 1). Majority students (82%) agreed that concept mapping should be included in curriculum (Graph 1).

D. M. Torre et al [28] described students' reaction in his study that concept maps fostered a positive connection between theory and practice. Students further described concept mapping as a teaching methodology, as a facilitator of knowledge integration and critical thinking, and finally, as a method which helped them in learning process. Ritchhart et al [29] found that concept maps as a metacognitive tool, can support student's self-reflection about their conceptions of thinking and thinking processes. In another study, students found that concept maps enhanced their capacity to develop clear concepts in pharmacology and in getting a comprehensive and accurate overview of the entire topic. This helped in quick revision before exams [21](Farida et al).

Students' reaction in present study also confirms views expressed in previous studies that concept mapping helps in developing deeper understanding, meaningful learning and critical thinking. Concept mapping is one of the tools of self-directed learning. Present system of medical education in India does not facilitate self-directed learning; this could be one of the reasons why students felt that concept mapping is time consuming.

Majority faculty members felt that concept mapping is a better teaching learning tool than lecture and demonstrations but it is time consuming (Graph 2). The questionnaire was focused on utility of concept maps and their feasibility (Table 6).

Conclusion

Concept mapping is a better teaching learning tool than lecture and demonstration methods. Teaching-learning with development of concept maps individually or collaboratively facilitates higher cognitive learning. Learning with development of concept maps in a group leads higher academic performance than learning with concept maps developed individually. Concept maps as a teaching-learning tool should be included in medical undergraduate curriculum to facilitate knowledge integration, meaningful learning and critical thinking.

References

1. Archie S. Golden. Lecture skill in medical education, Indian J Paediatr, 1989; 50:29-39.
2. Lalley J. Miller R. The learning pyramid: Does it point teachers in right direction, Education, 2007; 128(1):16.
3. Weick, K. E. Sensemaking in organizations, 1995; (Vol. 3). Sage.
4. Klein, G., Moon, B. M., & Hoffman, R. R. Making sense of sensemaking 1: Alternative perspectives. IEEE Intelligent Systems, 2006; 21(4):70-73).
5. Strike, K. A., & Posner, G. J. A revisionist theory of conceptual change . In R. A. Duschl & R. J. Hamilton (Eds.), Philosophy of science, cognitive psychology, and educational theory and practice. 1992; Albany, NY: State University of New York Press.
6. Demastes, S. S., Good, R. G., & Peebles, P. Students' conceptual ecologies and the process of conceptual change in evolution. Science Education, 1995; 79(6): 637-666.
7. Linn, M. C. Teaching for conceptual change: Distinguish or extinguish ideas. In S. Vosniadou (Ed.), International handbook of research on conceptual change. 2008; New York: Routledge.
8. Bransford, J., Brown, A. L., & Crocking, R. R. How people learn: Brain, mind, experience, and school. 2000; Washington, D.C: National Academy Press.
9. Linn, M. C., & Eylon, B. S. Science education: Integrating views of learning and instruction. In P. A. Alexander & P.H. Winne (Eds.), Handbook of educational psychology, 2006; 2nd edition. (pp. 511-44). Mahwah, NJ: Lawrence Erlbaum Associates.
10. Novak JD, Gowin DB. Learning how to learn. 1984; New York: Cambridge University Press.
11. Cañas, A.J. A summary of literature pertaining to the use of concept mapping techniques and technologies for education and performance support, 2003; . www.ihmc.us.
12. Mason, C.L. Concept mapping: A tool to develop reflective science instruction. Science Education, 1992; 76(1):51-63.
13. Ali Saeedi, Ali Akbar Saif, Hassan Asadzadeh, Soqra Ebrahimi Qavam. Comparing effectiveness of methods of presentation and providing concept maps

on reading comprehension.Euro. J. Exp. Bio., 2013; 3(2):545-550.

14. Bjork, R.A., & Linn, M.C. The science of learning and the learning of science -introducing desirable difficulties. APS Observer, 2006; 19(3).
15. Weinstein, C.E., & Mayer, R.E. The teaching of learning strategies. In Innovation abstracts 1983; 5: 4.
16. Scaife, M., & Rogers, Y. External cognition: How do graphical representations work? International Journal of Human Computer Studies, 1996; 45(2): 185-213.
17. Yavuz Erdoðan. An Investigation of the Effectiveness of Concept Mapping on Turkish Students' Academic Success, Journal of Education and Training Studies Vol. 2016; 4(6):1-9.
18. Horton, P. B., McConney, A. A., Gallo, M., Woods, A. L., Senn, G. J., & Hamelin, D. An investigation of the effectiveness of concept mapping as an instructional tool. Science Education, 1993; 77(1):95-111.
19. Farzane Saeidifard, Kazem Heidari, Moein Foroughi, Akbar Soltani . Concept mapping as a method to teach an evidence-based educated medical topic: A comparative study in medical students. Journal of Diabetes & Metabolic Disorders, 2014; 13:86.
20. Sylvia C Vink, Jan Van Tartwijk, Jan Bolk, Nico Verloop. Integration of clinical and basic sciences in concept maps: a mixed-method study on teacher learning. BMC Medical Education, 2015; 15:20.
21. Farida Qadir, Tabassum Zehra, Imrana Khan. Use of concept mapping as a facilitative tool to promote learning in pharmacology. Journal of the College of Physicians and Surgeons Pakistan, 2011; 21 (8):476-481.
22. Nesbit, J.C., & Adesope, O.O. Learning with concept and knowledge maps: A meta-analysis. Review of Educational Research, 2006; 76(3):413-448.
23. Clayton LH. Concept mapping. An effective, active teaching, learning method. Nurs. Educ. Perspect. 2006 Jul-Aug; 27(4):197-203.
24. Daley B, Shaw C, Balistrieri T, Glasenapp K, Piacentine L. Concept maps: A strategy to teach and evaluate critical thinking. J Nurs Educ. 1999; 38:1–6.
25. Sarhangi F, Masumi M., Ebadi A., Seyyed Mazhari M., Rahmani A. Comparing the effect of lecture- and concept mapping based learning on cognitive learning levels. Iranian Journal of Critical Care Nursing Spring. 2010; 3(1):1-5.
26. Hilda Leonor Gonza´lez, Alberto Pardo Palencia, Luis Alfredo Uman˜a, Leonor Galindo, Luz Adriana Villafrade M. Mediated learning experience and concept maps: a pedagogical tool for achieving meaningful learning in medical physiology students.Adv Physiol Educ, 2008; 32:312–316.
27. Anto´nio B. Rendas, Marta Fonseca, Patrý´cia Rosado Pinto. Toward meaningful learning in undergraduate medical education using concept maps in a PBL pathophysiology course. Adv Physiol Educ, 2005; 30:23–29.
28. D. M. Torre, B. Daley, Tracy Stark-Schweitzer, Singh Siddartha, Jenny Petkova, Monica Ziebert. A qualitative evaluation of medical student learning with concept maps. Medical Teacher, 2007; 29: 949–955.
29. Ritchhart, R., Turner, T., & Hadar, L. Uncovering students' thinking about thinking using concept maps. Metacognition and Learning, 2009; 4:145-159.

Original Article

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The Study of Anomalous Origin of Flexor Carpi Radialis Muscle

Shweta Solan

Abstract

Flexor carpi radialis [FCR] is a superficial flexor muscle of forearm and show variations in pattern of origin, abnormal fusion with other muscles, as well as insertion pattern. The objective of the study was to enumerate variations of FCR muscle and to establish a clinico-anatomical correlation. The present study was conducted on bilateral upper limbs of thirty cadavers, irrespective of sex, over a period of four years. The study revealed two abnormal pattern of origin of FCR in two cadavers. In one cadaver, FCR has additional B/L head of origin from Biceps tendon insertion. In another cadaver, U/L fused origin of FCR with Pronator teres was found. This study has relevant implication related to clinical and radiological diagnosis of neurovascular compression involving forearm, and also various reconstructive surgeries involving forearm structures.

Keywords: Flexor Carpi Radialis; Pronator Teres; Forearm; Median Nerve.

Introduction

Flexor carpi radialis is one of the superficial flexor group of muscles of the anterior compartment of the forearm, along with pronator teres, palmaris longus, flexor digitorum superficialis and flexor carpi ulnaris. It takes origin from the medial epicondyle of the humerus as common flexor origin.The fusiform muscle belly becomes tendinious in the middle of forearm and is inserted into the palmar aspect of base of second and third metacarpal bones. It derives its nerve supply from median nerve in forearm [1]. Anatomical variations of FCR muscle include its unusual origin and occurrence, attachments, duplication including presence of additional belly and/or tendon, abnormal fusion with other muscle, and also regarding insertion pattern [2-7]. The objective of this study is to identify and document variations of FCR muscle and to establish an anatomical basis which can be of great help to radiologist during diagnosis and surgeons during reconstructive surgeries involving neurovascular and musculotendinous pathologies.

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Materials and Methods

The present study was conducted on sixty upper limbs of thirty cadavers of different ages, irrespective of sex. It was carried out during routine dissection of superior extremity for teaching undergraduate students in the department of Anatomy, Kallinga institute of medical sciences, over a period of four years. Flexor compartment of arm and forearm were dissected according to standard dissection technique and all the muscles were exposed carefully. FCR muscles were isolated from origin to insertion and were carefully observed, for any variations regarding their origin, course, abnormal fusion with other muscles, nerve supply and insertion. All variations were carefully noted and their photographs were taken.

Result

Meticulous dissection of forearm was done in all cadavers, and structures were exposed. In all 58 upper

limbs, no significant abnormality in FCR was noted. Only two of cadavers showed U/L abnormal FCR muscle as described below.

In one of the 65 year old female cadaver, left upper limb showed additional slip of origin of FCR from lower end of insertion of biceps brachii muscle and bicipital aponeurosis. This additional slip was fused with fibres of pronator teres, almost covering it and making it unrecognisable from above. Pronator teres was recognised by the entrance of median nerve in it [Figure 1]. When muscle fibres of additional head of FCR were dissected, then pronator teres muscle become evident. The tendon of FCR was found to be fused with pronator teres from origin to insertion [Figure 2]. Other muscles were normally arranged with normal pattern of neurovascular structures. Right upper limb showed no abnormality.

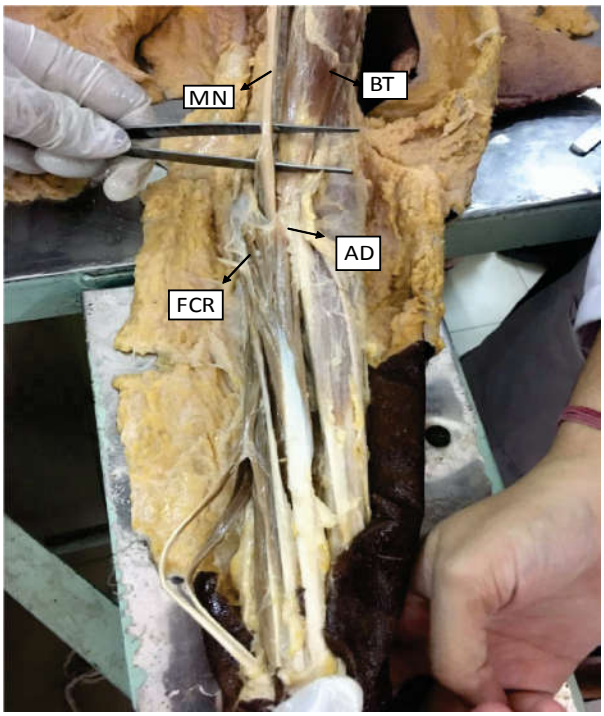

Fig. 1: Flexor carpi radialis[FCR], additional head of flexor carpi radialis[AD], Median nerve[MN], Biceps tendon insertion[BT]

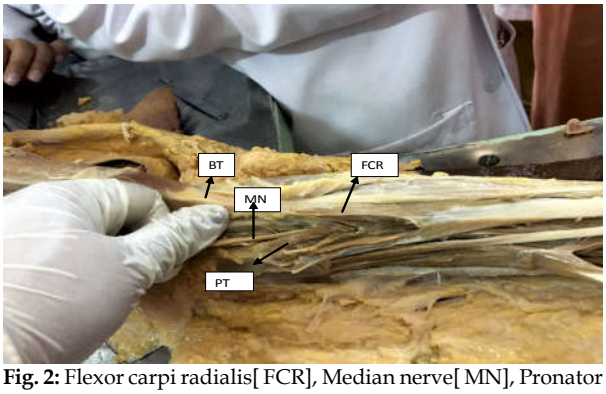

Fig. 2: Flexor carpi radialis[FCR], Median nerve[MN], Pronator teres[PT], Biceps tendon[BT]

In another 50 year old male cadaver, right forearm showed the origin of FCR from medial epicondyle and from fibres of Pronator teres, showing fusion.FCR covers Pronator teres upto its insertion and the insertion of pronator teres can be seen by carefully retracting FCR [Figure3]. Neurovascular structures like median nerve, brachial artery, etc were normal. Left forearm showed no structural abnormality.

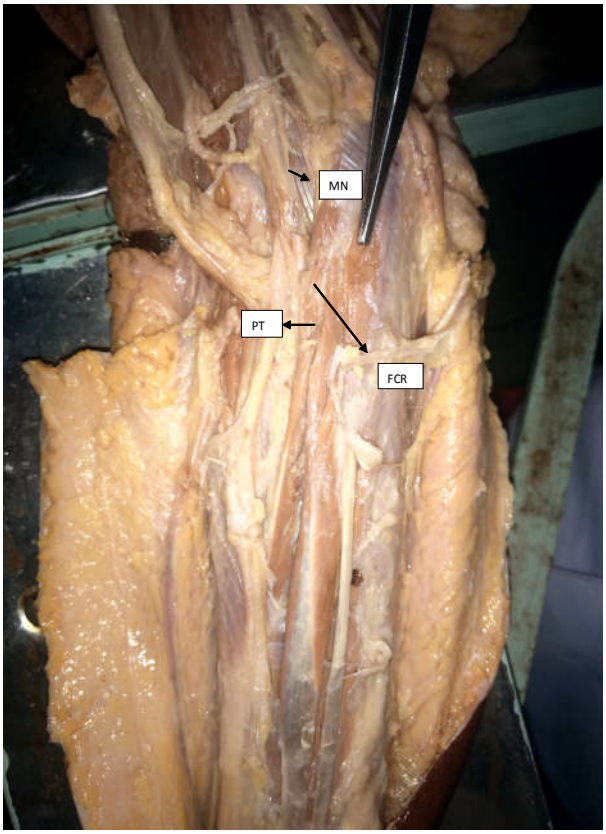

Fig. 3: Flexor carpi radialis[FCR], Pronator teres[PT], Median nerve[MN]

Discussion

Various anatomical anomalies of musculotendinous structures around the wrist are known [4]. They are often found by chance during imaging studies and surgical procedures, and sometimes perceived when they cause certain pathologic conditions, such as compression neuropathy [8]. Variations of muscles of flexor compartment of forearm have always been an area of interest for anatomist, radiologist as well as vascular surgeons. Variations in occurrence, origin, duplication, fusion with other muscles, and insertion have been reported earlier [2-7]. Carleton A et al in 1935 described a muscle naming Flexor carpi radialis vel profundus, taking origin from front and lateral

side of radius and inserting into third and fourth metacarpal bone [2]. Nakahshi T et al in 1987 reported a case of fusion of FCR with Extensor carpi radialis brevis around the wrist [3]. Dodds SD et al in 2006 reported FCR muscle with anomalous origin from distal part of radius [4]. Scott F M Duncan et al in 2006 reported a case of Flexor carpi radialis brevis originating from beneath of FCR muscle [5]. Mantovani G et al in 2010 described six case reports of anomalous Flexor carpi radialis brevis muscle from volar aspect of forearm [6].

Trivedi S et al in 2015 reported a case of musculotendinous slip from insertion of Biceps brachii to Pronator teres and FCR [7]. Deopujari et al in 2014 [9] and Madhumita Dutta et al in 2016 [10], reported a study regarding additional head of FCR originating from junction of Biceps tendon and Bicipital aponeurosis similar to our study. But difference is that in those study fibres of FCR were not fused with fibres of Pronator teres in any aspect.

Moreover, no case had been reported earlier where fibers of FCR were found to be fused with Pronator teres. In present study, two cases were reported . In one cadaver, origin ofadditional head of FCR from junction of Biceps tendon and Bicipital aponeurosis were found and this muscle completely covered Pronator teres and was fused with it from origin to insertion. In another cadaver, only origin of FCR was found to be fused with Pronator teres. This fusion reflects embryological basis related to development of upper limb muscles [10]. Such variations have been reported as clinically relevant implicating aponeurosis causing median nerve entrapment, compression of brachial artery, pronator syndrome etc. The knowledge of such variation of FCR can be of great help in various reconstructive surgeries [11] and neurovascular surgeries involving wrist and hand. One of the main clinical implication of FCR is graft [12] and tendon transfer surgery [13]. Biomechanics of wrist joint can be altered due to imbalanced structure of FCR [14].

Conclusion

Various earlier study had reported bicipital origin of FCR, but abnormal, partial or complete fusion with Pronator teres had not been reported earlier. Knowledge of present study highlighting anatomical variant of FCR muscle seemed to be relevant and clinically noteworthy and it would be of great help in various reconstructive, neurovascular, tendon transfer and graft surgeries involving forearm, wrist and hand.

Refrances

1. Standring S, Johnson D. Gray's anatomy: The Anatomical Basis of Clinical Practice. 40th ed., Edinburg: Churchill Livingstone (Elsevier); 2008: 845-46.
2. Carleton A. Flexor carpi radialis brevis vel profundus. J Anat. 1935; 69(Pt 2):292–293. [PMC free article][PubMed].
3. Nakahashi T, Izumi R. Anomalous interconnection between flexor and extensor carpi radialis brevis tendons. Anat Rec. 1987; 218(1):94–97. [PubMed.
4. Dodds SD. A flexor carpi radialis brevis muscle with an anomalous origin on the distal radius. J Hand Surg Am. 2006; 31(9):1507–1510. [PubMed].
5. Duncan SFM, McCormack RR Jr, Roberts CC. Characteristics of flexor carpi radialis brevis tendon on magnetic resonance imaging and its use in basal joint arthroplasty. Radiology Case Reports. [Online] 2006; 1(1):24-26.
6. Mantovani G, Lino W, Jr, Fukushima WY, Cho AB, Aita MA. Anomalous presentation of flexor carpi radialis brevis: a report of six cases. J Hand Surg Eur 2010; 35(3):234–235. [PubMed].
7. Trivedi S, Sinha MB, Sharma DK, Rathore M, Siddiqui AU. Abnormal musculotendinous slip from Biceps Brachii to Pronator Teres: A Case Report. IJBAR 2015; 6(01): 64-66.
8. Peers SC, Kaplan FT. Flexor carpi radialis brevis muscle presenting as a painful forearm mass: case report. J Hand Surg Am. 2008; 33(10):1878–1881. [PubMed].
9. Deopujari R, Quadir N, Athavale S, Gajbhiye V, Kotgirwar S. Variant Bicipital Aponeurosis: A Cadaveric Study. PJSR 2014; 7(2):43-46.
10. Madhumita Datta, Phalguni Srimani, Nabanita Chakraborty, Alpana (De) Bose. Anomalous Bicipital Origin of Flexor Carpi Radials Muscle: A Cardaveric Study. Int J Anat Res 2016; 4(1):1878-1881. DOI: 10.16965/ijar.2016.101.
11. Robert W.Wysocki,MD, Mark S et al; Thumb Carpometacarpal Suspension Arthroplasty Using Interfence and Clinical Results; JHS 2010 June; 35.
12. Wallis KL, Hoon Tay P. Re: S. Umarji and M. Pickford. A novel technique for harvesting a split flexor carpi radialis tendon graft. J Hnad Surg Eur. 2008 33: 817-8 J. Hand Surg Eur 2009 oct; 34(5):700-1.
13. Friden J, Lovering RM, Lieber RL, Fibre length variability within the Flexor carpi ulnaris and Flexor carpi radialis muscles: implications for surgical tendon transfer. J Hand Surg Am 2004 Sep; 299(5):909-14.
14. Werner FW. Short WH, Palmer AK, Sutton LG, Wrist tendon forces during various dynamic wrist motion. J Hand Surg Am 2010 Apr; 35(4):628-32.

Revised Rates for 2017 (Institutional)

Title	Frequency	Rate (Rs): India		Rate ($):ROW	
Community and Public Health Nursing	3	5000	4500	357	300
Dermatology International	2	5000	4500	357	300
Gastroenterology International	2	5500	5000	393	340
Indian Journal of Agriculture Business	2	5000	4500	500	450
Indian Journal of Anatomy	4	8000	7500	571	500
Indian Journal of Ancient Medicine and Yoga	4	7500	7000	536	500
Indian Journal of Anesthesia and Analgesia	4	7000	6500	500	450
Indian Journal of Biology	2	5000	4500	357	300
Indian Journal of Cancer Education and Research	2	8500	8000	607	550
Indian Journal of Communicable Diseases	2	8000	7500	571	500
Indian Journal of Dental Education	4	5000	4500	357	300
Indian Journal of Emergency Medicine	2	12000	11500	857	800
Indian Journal of Forensic Medicine and Pathology	4	15500	15000	1107	1050
Indian Journal of Forensic Odontology	2	5000	4500	357	300
Indian Journal of Genetics and Molecular Research	2	6500	6000	464	400
Indian Journal of Hospital Administration	2	6500	6000	464	429
Indian Journal of Hospital Infection	2	12000	9000	857	800
Indian Journal of Law and Human Behavior	2	5500	5000	393	350
Indian Journal of Library and Information Science	3	9000	8500	643	600
Indian Journal of Maternal-Fetal & Neonatal Medicine	2	9000	8500	643	600
Indian Journal of Medical & Health Sciences	2	6500	6000	464	410
Indian Journal of Obstetrics and Gynecology	4	9000	8500	643	600
Indian Journal of Pathology: Research and Practice	4	11500	11000	821	780
Indian Journal of Plant and Soil	2	65000	60000	4623	4100
Indian Journal of Preventive Medicine	2	6500	6000	464	410
Indian Journal of Research in Anthropology	2	12000	11500	857	800
Indian Journal of Surgical Nursing	3	5000	4500	357	300
Indian Journal of Trauma & Emergency Pediatrics	4	9000	8500	643	600
Indian Journal of Waste Management	2	9000	8000	643	579
International Journal of Food, Nutrition & Dietetics	3	5000	4500	357	300
International Journal of Neurology and Neurosurgery	2	10000	9500	714	660
International Journal of Pediatric Nursing	3	5000	4500	357	300
International Journal of Political Science	2	5500	5000	550	500
International Journal of Practical Nursing	3	5000	4500	357	300
International Physiology	2	7000	6500	500	450
Journal of Animal Feed Science and Technology	2	78000	70000	5571	5000
Journal of Cardiovascular Medicine and Surgery	2	9500	9000	679	630
Journal of Forensic Chemistry and Toxicology	2	9000	8500	643	600
Journal of Geriatric Nursing	2	5000	4500	357	300
Journal of Medical Images and Case Reports	2	5000	4500	357	300
Journal of Microbiology and Related Research	2	8000	7500	571	520
Journal of Nurse Midwifery and Maternal Health	3	5000	4500	357	300
Journal of Organ Transplantation	2	25900	25000	1850	1700
Journal of Orthopaedic Education	2	5000	4500	357	300
Journal of Pharmaceutical and Medicinal Chemistry	2	16000	15500	1143	1100
Journal of Practical Biochemistry and Biophysics	2	5500	5000	393	340
Journal of Social Welfare and Management	3	5000	4500	357	300
New Indian Journal of Surgery	4	7500	7000	536	480
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Determination of Sex from Upper End of Humerus

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Abstract

Identification of sex from remains of skeleton is an important demographic assessment in medico legal investigations and anatomists are frequently consulted by law enforcement authorities for it. Present study is conducted on 50 human humeri (all are dry, and undamaged. 25 are male and 25 are female) Five parameters are studied. The mean values of all parameters are significantly higher in males than in females (P<0.001) with univariate analysis. Not a single parameter gives us an idea of sex of humerus with 100% accuracy. The single best parameter is CA (Circumference of anatomical neck of humerus) with an accuracy of 64 % in males and 68 % in females.

Keywords: VDH (Vertical Diameter of Humerus); CS (Surgical Neck of Humerus); DP(Demarcating Points); SD(Standard Deviation); Skeleton; Anatomist; Univariate; Osteometer.

Introduction

Identification of sex from skeletal is of great medico legal and anthropological significance.

Anatomists are consulted frequently by law enforcement authorities regarding identification of skeleton found under suspicious circumstances while anthropologist are also interested in finding the age, sex, stature and other details about skeleton remains found during archeological excavations [1].

Traditional methods for assignments of sex on pattern of skeletal morphology do not have an explicit basis. Visual impression of bones can seldom be accurate because of many pitfalls associated with subjective assessment of the observer. Identification of sex from skeleton is an important demo graphic assessment in medico legal investigation.

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Although the analysis of DNA is the most reliable method for sex determination but it is expensive and time consuming [2]. In the absence of DNA, results of sex of skeleton can be identified either by anthropometric method or morphological method.

Morphological approach is based on examination of bones and is not always reliable as age affects the skeleton. It also depends on experience of examiner. Anthropometric analysis relies on bone measurements [3].

The determination of sex, age and estimation of stature from bones play an important role in identifying unknown bodies, part of bodies or skeletal remains [4]. Determination of sex of the skeletal remains of an individual from an examination of single bone except the hip bone is considered to be difficult task and has been the subject of continuous investigations. Even when the entire human body, pelvic and skull are available, not more than 95% accuracy can be achieved.

In medico legal practice statements on probable sex of decomposed body or part of bodies are often expected even during autopsy for sexing the skeleton. Various studies have been done on various bones. The accuracy of sex determination depends on the type and condition of the bone, age of the subject, the degree of fragmentation of the bones and biological

variability [5]. Obviously more the quantity of skeletal remains available more accurately one can comment on sex of an individual.

Humerus is the longest and the largest bone in the upper limb [6]. It has expanded upper and lower ends with a shaft. Upper end consists of head,lesser and greater tubercle, upper part of intertubercular sulcus (bicipital groove) and neck. Head is articular, spheroidal and forms about one-third of a sphere. It articulates with glenoid cavity of scapula to form shoulder joint. Lesser tubercle presents a smooth muscular impression which projects forward just beyond the head. The lateral margin of the lesser tubercle is sharp and is separated from the greater tubercle by the upper part of the intertubercular sulcus. Greater tubercle occupies the most lateral part of the upper end and its convex lateral surface forms the rounded contour of the shoulder.

Humerus has anatomical neck and surgical neck. Anatomical neck is a constriction that immediately succeeds the head. Surgical neck is a constriction between the expanded upper end and the cylindrical shaft of the humerus.

Many workers have studied humerus in past but all that can help us in identifying sex of only 80% humerus, moreover many parameters show overlap between male & female values and make it more difficult to comment on sex with 100% accuracy. This may be due to genetic nutritional and socioeconomical difference in individual or may be due to hypo masculinity in female humerus and hyper masculinity in male [3]. Present study is focused on measurements of humerus and evaluates the difference on sex present in the morphology through statistical analysis. In this study we have also compared present data with other workers.

Aim of Present Study

To achieve highest possible accuracy in establishing sex from humerus with available resources.

Materials and Methods

50 adult humeri of known sex are studied from Bone Bank of Department of Anatomy MGM Medical College, Aurangabad. All are dry, free of damage or deformity. The personal records of all humeri for age sex and race are available with the bone bank.

The Instruments which are Used for Measurements of Various Parameters of Humerus are as Follows.

1. Scale
2. Osteometer
3. Vernire caliper
4. Scientific balance and weight
5. Non elastic thread
6. Marker pencil

The following measurements are taken for each humerus.

Weight(W)

Weight of each dried humerus is recorded with the help of scientific balance in grams

Total Length(L)

Functional length of humerus i.e. distance between upper and lower end in anatomical position is recorded in mms with the help of osteometer.

Circumference of head of anatomical neck (CA)

The circumference of the anatomical neck of the humerus is measured by marking a fixed point at groove opposite to the greater tubercle on the anatomical neck with a marker pencil and running the non-elastic thread along the groove starting from the fixed point and back to it. The length of the thread is recorded on scale in mms.

Circumference of surgical neck (CS)

It is measured at a point 1cm below the lowest point of the margin of articular surface of the head of humerus: the point is in line with medial epicondyle. It is measured with the help of non-elastic thread by the same method as that of CA

Vertical diameter of head (VDH)

This is the maximum diameter of head, in vertical plane of head of humerus. This is measured by Vernier caliper in mms.

Observations

In present study 50 fully ossified ,dried,non damaged humeri of known sex from Bone Bank of M. G. M Medical. College are studied Each humerus is measured for five parameters. The measurements are tabulated and statistically analyzed. For each parameter mean standard deviation, demarcating points are calculated.

Table 1: Statstical Analysis of Various Parameters of Male Humeri

Measurements	Mean	SD	Range	95 % of CI	DP
W (gms)	115	12.3	99-141	109-121	>125
L(mms)	314	13.4	285-349	308-320	>314
CA(mms)	133	6.23	120-143	13O-136	>132
VDH(mms)	43.7	2.07	39-47	43-45	>43
CS(mms)	91.8	6.53	78-106	89-95	>96

Table 3: Statstical Analysis of Various Parameters of Female Humeri

Measurements	Mean	SD	Range	95% of CI	DP
W(gms)	74.1	16.2	51-125	68-80	<95
L(mms)	286	16	250=325	280-292	<280
CA(mms)	116	8.03	102-132	113-118	<120
VDH(mms)	37.8	2.79	33-43	37-39	<38
CS(mms)	79.9	7.02	68-96	77-83	<75

Discussion

Humerus is commonly studied long bone. In present study we have analyzed the data, compared the results with previous study. We measured five parameters of humerus and from these parameters we have determined the sex of humerus.

Weight

Though weight has been emphasized in the past as an important and reliable parameter for determination of sex but with all resources available we could get only study done by singh etal with which weight measurements compared.

Table 3: Comparison of Weight of present study with different workers

Sr. No.	Name of Worker	Male				Female			
		N	Mean	SD	DP	N	Mean	SD	DP
1	Singh et al	216	132	26	7133	74	82	17	64
2	Present Study	50	115	12.3	7125	50	74.1	16.1	95

The percentage of humeri identified with 100% accuracy by weight alone is 24% for male and 96% in female. Weight is highly significant in present study with $p < 0.001$

Length of Humerus

Length of humerus is statistically very much significant parameter with $p<0.001$

Following table 4 shows comparison of present study with different workers. It is evident that mean, S.D. and demarcating point values are more in European races. Percentage of humeri identified with 100% accuracy by using length alone is 52% in males and 36% in females in present study.

Table 4: Comparison of Length of Humerus of present study with different workers

Sr. No	Name of worker	Male				Female			
		N	Mean	S.D	D.P	N	Mean	S.D	D.P
1	Thiem	-	338	-	-	-	305	-	-
2	Khan	-	322	-	-	-	290	-	-
3	Singh et al	216	313.9	14.3	>324.4	74	279	14.9	<271
4	Panse A.A	71	312.54	17.4	>318.8	29	283.4	11.8	<253.1
5	Mall G et al	64	334			79	307		
6	Present study	50	314	13.4	>314	50	286	17.3	<280

It is also appreciated from the table that mean lengths are approximately same in all Indian studies.

Vertical Diameter of Head (VDH)

Vertical diameter of head is most commonly studied parameter of humerus and is anonymously relied by all workers.

Table 5: A comparison of mean VDH values observed by different workers

Sr. No.	Name of Worker	Male				Female			
		N	Mean	SD	DP	N	Mean	SD	DP
1	Khan (1959)	-	48	-	-	-	40.5	-	-
2	Panse A. A. (1979)	71	43.1	3.1	756.5	29	39.4	5.7	< 33.8
3	Mall G. 2001	-	50	-	-	-	44	-	-
4	Maryan Sten excel	55	49	3.2	746.02	48	43.2	2.5	< 46.02
5	Present study	50	43.7	2.07	743	50	37.8	2.79	< 38

A comparison of mean VDH values observed by different workers can be seen in table 5. Panse A. A [7] in her conclusion stated that vertical diameter of humerus is a reliable parameter for determination of sex of humerus, mean values observed in present study are close to the study of Panse A. A.

In present study humeri identified with 100% accuracy by this parameter alone is 45.9% in males and 56.5% in females

Circumference of Head at Anatomical Neck (CA)

Rothes P. Petalx [8] studied this parameters in 49 cases and concluded that it is significant parameter.

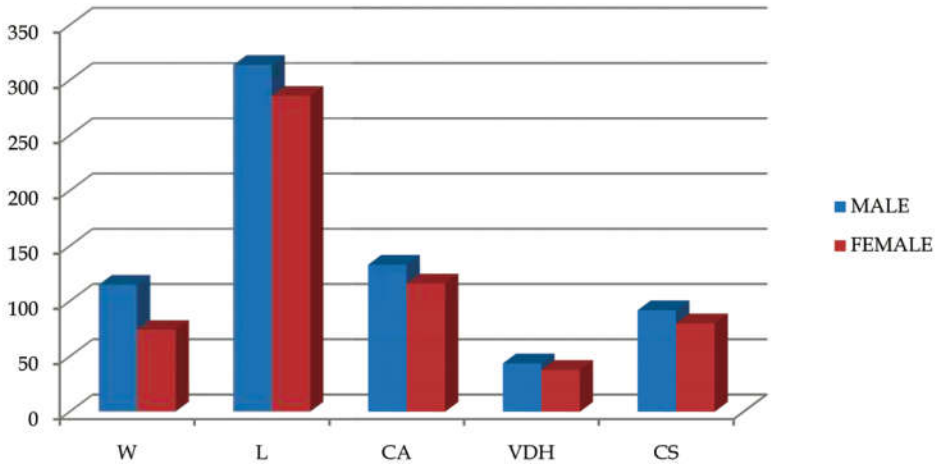
Table 6:

Male				Female			
N	Mean	S.D.	D.P.	N	Mean	S. D.	D. P.
25	133	6.23	>132	25	116	8.03	<120

In present study, percentage of humeri identified with 100% accuracy by this parameter is 64% in males & 68% in females.

Circumference of Surgical Neck of Humerus (CS)

This parameter was studied for first time in this study. The percentage of humeri sorted by this



Graph 1: Bar chart showing mean values of male and female measurements

parameter alone with 100% accuracy is 28% in male and 20% in female. It has been observed that not a single parameter gives us 100% accuracy about the sex of humerus and hence all parameters are considered together.

Conclusion

Five parameters are studied in 50 human humeri of known sex. Measurements obtained are compared with values obtained by previous workers. All these parameter are analyzed statistically and percentage of humeri sorted with 100% accuracy using individual parameter is calculated.

Circumference of anatomical neck of humerus is found to be most reliable parameter with 64% accuracy in male and 68% accuracy in female.

Parameters like Weight, Length VDH, CS can be

helpful in sorting sex of humerus.

References

1. Krogman W. M. (1962):' The human Skelton in forensic medicine.' 3rd edition Charles C.Thomous Springfield, Illinois U.S.A.
2. Gibbon V, Paximadis M, Ruff Pet al Novel methods of molecular sex identificationfrom skeletal tissue using the amelogenin gene Forensic Sci Int. Genet. 2009; 3:74-9.
3. Zelina Basic, Lvana ANteric et al sex determination in skeletal remains from medieval Eastern Adriatic coast- discriminant function analysis of humeri. Croatian Medical Journal 2013.
4. Modi(2001): Modi's Medical Jurisprudence and Toxiology. 22nd edition.
5. Study of sexual dimorphism of humerus in Tamilnadu region Anil kumar Reddy, Sheela G.J. Internationational journal of Medical Research and Health Sciences. 2013; 3(1).
6. Susan Standring's 40th edition of GRAY'S Anatomy. The anatomical basis of clinical practice: pg796-797.
7. Panse A.A."Estimation of strature and determination of sex from appendicular skeleton".
8. Rother P. "The determination of age and sex from measure of the humerus Anat. Anz. 1977; 142(3):243-54.

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A Study on the Shape of Sella Turcica

Swapna R. Chavan*, A.S. Katti, N.G. Herekar*****

Abstract

The importance of size and shape of the sella turcica in connection with the occurrence of symptoms of pituitary diseases has long been recognized. Present study was aimed to study normal shape of Sella turcica by radiographs. In the present study, lateral radiographs of skulls of four hundred and forty seven subjects of known age (between 13 to 55 years) and sex (two hundred and thirty seven males; two hundred and ten females) were studied. The Sella Turcica is classified into three basic shapes Oval, Round & Flat. Oval shape is most commonly found and flat least commonly found in Maharashtrian population.

Keywords: Sella Turcica; Computed Radiographs; Pituitary Gland; Maharashtrian Population.

Introduction

The sella turcica is a structure easily recognized on lateral cephalometric radiographs and often used for cephalometric analysis. This makes it a good source of additional diagnostic information related to any pathology of the hypophysis, or to the various syndromes that affect the craniofacial region. According to Isadore Meschan [1], the deformity of sella turcica is an important and only clue that abnormality exists within the cranium; hence a familiarity with its anatomy and radiological appearance is essential.

The sella turcica, a deep depression in the floor of the skull which contains the pituitary gland. This word is translated from the Latin as "Turkish saddle", *sella* meaning saddle and *turcica*- "of the Turks". (called the *sella equestris* by Romans) the phrase "Turkish saddle" appeared, used by Europeans as a generic reference to any saddle with a high back and front. And so the rationale use of *sella turcica* in anatomy, which began appearing in medical texts in the 17th century: the saddle-like fossa of the sphenoid bone which has a tall posterior "cantle" and anterior "pommel" (A. Carey) [2].

Schuller[3] believed that the difference in the shape of the sella mainly dependant on the degree of development of sphenoid sinus. Lying under floor these must influence the changes in the sella turcica in pathological states. The radiographic interpretation and significance of changes in sella turcica are dependent upon the accurate knowledge of anatomy of this structure and closely related parts of brain and cranium [3].

According to Isadore Meschan [1], the deformity of sella turcica is often the only clue that abnormality exists within the cranium; hence a familiarity and knowledge with its anatomy and radiological appearance is essential.

Clinicians should be aware of the normal radiographic appearance and morphometric variations of this area, in order to identify and investigate deviations that may reflect pathological situations, even before these become clinically apparent (M. Andredaki) [4].

Material & Method

A total four hundred and forty seven normal lateral view radiographs of skull were included in the study.

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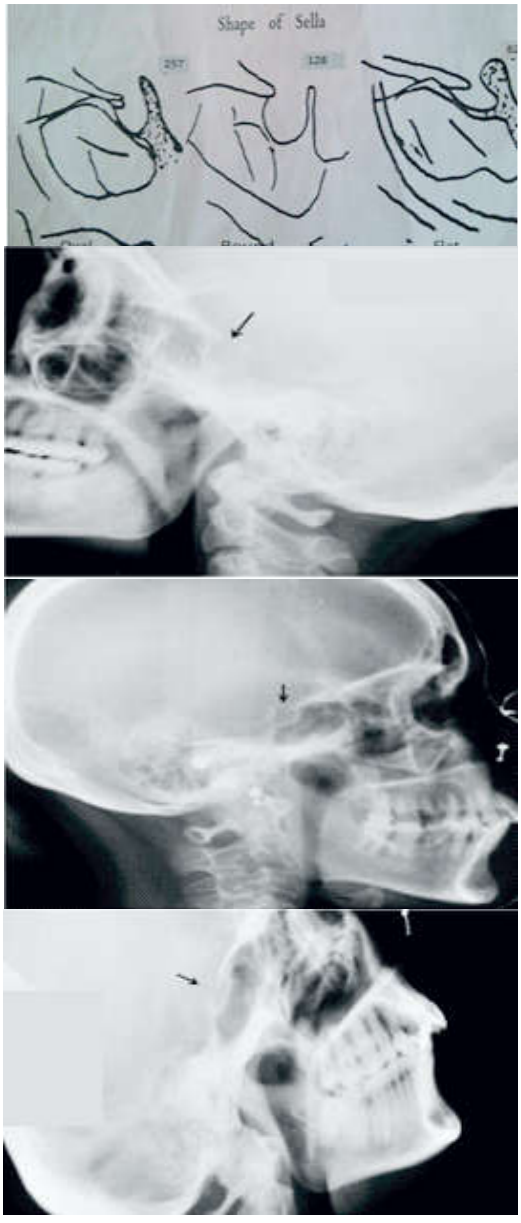
Age groups selected were 13 to 55 years and out of total radiographs 237 male and 210 female computed radiographs obtained and measurements taken in radiology department of various institutes. Computed radiography (CR) method used. Radiographs of both sexes were taken with subject position – Lateral rotation of skull. X-ray tube focused on head. Cassette is placed below head. The center point is over the hypophyseal fossa – 1 cm above the orbitomeatal line and 2.5 cm anterior to the external auditory meatus with head in the true lateral position (Sutton) [3]. Exposure is made with tube voltage 50 – 90 KVP. The distance was 100 cm fixed between x-ray tube and film plate.

Radiographs of poor quality and abnormal sella turcica were excluded from the study.



Pic. 1: Different shapes of Sella Turcica (Agrawal et al 1968)

Radiographs diagnosed as normal by experienced radiologist were in included.

For present study shape of Sella Turcica divided into three (picture plate 1 shows).

1. Oval
2. Round
3. Flat

The age group chossen for present study is thirteen years to fifty five years as; in children the hypophyseal fossa increases with the growth of pituitary gland and becomes smaller if the gland decreases in size. The pituitary gland enlarges during the period of active growth, results in sella to enlarge with it. Later the pituitary gland may decrease in size but sella remain unchanged (Taveras and Wood) [5]. As age advances (result of age) atrophy of dorsum sellae may occur (Schulller) [3].

Observation

The results obtained are summarized in Table 1, Table 2, Table 3.

A total of 447 subjects were involved in study. Of this , 237 males and 210 females.

The various anatomical shapes of sella turcica seen in the study are shown in Table 1. The prominent shape of sella studied is oval [Figure 1].

It is observed that oval shape is most common (57.5%) in whole population. Next common shape is round (28.6%) and the rare shape is flat (13.9%).

Females

- In females, Oval shape is most common (51.42%), then next common shape found is round (34.76%) and rare shape is flat (13.80%).
- Percentage of round shape goes on increasing, whereas percentage of flat shape decreases with age.

Males

- Almost similar pattern found in that of Males.
- In 13-25 years age group percentage of flat shape is more than round whereas in 26 - 40 and 41 - 55 years age groups round shape is more common than flat.
- In males, Oval shape is most common (62.8%), then next common shape found is round (23.2) and rare shape is flat (13.9%)

Table 1: Showing shape of sella turcica in whole sample size (M & F)

Shape	Female	Male	Total	%
Oval	108	149	257	57.5
Round	73	55	128	28.6
Flat	29	33	62	13.9
Total	210	237	447	100.0

$X^2 = 7.73$ p = 0.02, significant
Interpretation:- Shape of Sella turcica is dependent of Sex

Table 2: Distribution and comparison of males according to shape of sella turcica in different age groups

Age Group in years	Shape of sella turcica in males						Total
	Oval		Flat		Round		
	No.	%	No.	%	No.	%	
13 to 25	44	58.6	16	21.3	15	20	**75**
26 to 40	51	63.0	8	9.9	22	27.2	**81**
41 to 55	54	66.7	9	11.1	18	22.2	**81**
Total	**149**	**62.8**	**33**	**13.9**	**55**	**23.2**	**237**

$X^2 = 5.68$ p = 0.22, Not significant
Interpretation:- Shape of Sella turcica is independent of age in males

Table 3: Distribution and comparison of females according to shape of sella turcica in different age groups

Age Group	Shape of sella turcica in females						Total
	Oval		Flat		Round		
	No.	%	No.	%	No.	%	
13 to 25	37	47.4	23	29.5	18	23.1	**78**
26 to 40	44	60.3	03	4.1	26	35.6	**73**
41 to 55	27	45.8	03	5.1	29	49.2	**59**
Total	**108**	**51.42**	**29**	**13.80**	**73**	**34.761**	**210**

$X^2 = 30.42$ p = 0.00004, significant
Interpretation:- Shape of Sella turcica is dependent of age in females

Discussion

The sella turcica has been a subject of research for many workers.

The normal variation in the measurement of sella turcica were studied by Gordon and Bell (1921) [6], Enfield (1928) [7], Kornblum (1932) [8], Haas (1954)9, Pendegrass et al (1956)10, Jupe and Northfield (1956)11, Mahmoud (1958) [12], Khanna (1962)[13], Lal et al (1965) [14], Agrawal et al (1968) [15].

Over 100 skulls 0f both sexes studied By Fitzgerald (1910) [16] and determined varying shapes of the fossa by series of cast.

Camp (1924) [17] classified the normal sella turcica into three types circular, oval and flat. And also mentioned the typical sellar changes associated with intra-sellar tumours as 1) Uniform circular enlargement of sella turcica 2) erosion and erection of dorsum sellae and 3) depression of sellar floor which may show a double line.

However in1949 camp stated the fact is that "the circular uniformly enlarged sella, long recognised as characteristic of pituitary tumour may be produced by tumours situated elsewhere within cranial cavity"

Jones RM [18] in 2004 reported that the anatomy of sella turcica is variable in size and shape. He also classified sella turcica into three types: round, oval, flat. It can also be deep or shallow in both (children and adults).

M. Andredaki (2007) [4] Selected standardised lateral cephalograms of 184 healthy Greeks (91 males and 93 females) between the age group of 6 to 17 years. The tracings were superimposed using procrustes method and the average shape was computed. Principle component analysis (PCA) was used to asses shape variability. The data was correlated with centroid size, age and gender.

A. D. Zagga et al (2008) [19] classified the shape of the sella turcica into three types: round, oval and flat. It can also be deep or shallow in both children and adults. The floor of the sella turcica which in most cases is concave may be, flat or even convex. A total of 228 subjects were involved in this study. Of this 171 were males, and 57 were females.

- Table no. 4 shows that most commonly found shape is oval.
- It was noted among shape of sella turcica, majority of the workers have found least percentage of Flat sella, but B. N. Lal et al (1965) [14] and G. N.

Agrawal et al (1968) [15] observed least percentage of round shape.

- In present study least found shape is Flat sella., similar findings are mentioned by Camp (1924) [17], Heublein (1946) [20], Isadore Meschan (1975)1, S. K. Bhargava et al (1978) [21].
- The percentage of oval shape given by A. D. Zagga (2008) [19] are higher than present study.
- The sella turcica shape percentages of present study correlate with that of camp (1924) [17], S. K. Bhargava et al (1978) [21].
- Bhargava (1978) [21] has studied 1100 normal individuals (free from neurological ailments) to measure normal sella turcica in lateral view of skull taken at a constant focus film distance of 40" The shape of sella in present series is oval 60 percent, circular 24.8 percent and flat 15.2 percent.

Table 4: Showing comparison of sella turcica shape in male's of present study with the findings of previous studies.

Series	Oval %	Round %	Flat %
Camp (1924)[17]	58	25	17
Heublein (1946)[20]	53	23	19
B. N. Lal et al (1965)[14]	64.75	17.19	18.06
G. N. Agrawal et al (1968)[15]	62.8	18.2	19
Isadore Meschan (1975)[1]	58	24.4	17.2
S. K. Bhargava et al (1978)[21]	60	24.8	15.2
A. D. Zagga (2008)[19]	83	11	6
Present study	57.5	28.6	13.9

Table 5: Showing age group wise comparison of sella turcica shape in Male's of present study with the findings of previous studies

Series	13-25			26-40			41-55		
	Oval %	Flat %	Round %	Oval %	Flat %	Round %	Oval %	Flat %	Round %
B. N. Lal et al (1965)[14]	55.0	29.3	16.6	73.0	1.9	24.4	67.2	6.56	26.2
G. N. Agrawal et al (1968)[15]	53	28	19	70	4	26	65	7	28
Present study	52.9	25.4	21.5	61.6	7.14	31.16	57.8	8.57	33.57

- Table 5 shows the most predominant shape found is oval. Second most common shape is round except in 13 – 25 years age group where flat shape is more common than round.
- In the study of B. N. Lal et al (1965) [14] and G. N. Agrawal et al (1968) [15] as the age advances percentage of flat shape decreases whereas oval and round shape increase comparatively. Exactly similar findings are observed in present study.
- Thus our study correlates well with B. N. Lal et al (1965) [14] and G. N. Agrawal et al (1968) [15].
- Predominant oval and round shape with the advancement of age may implies that the depth of sella keeps on increasing till much later age than length of sella (Lal et al) [14].
- This increase in depth is at the cost of sphenoid sinus (Agrawal et al) [15].

Summary & Conclusion

Total four hundred and forty seven (237 male and 210 Female) lateral view radiographs of skull of age 13 to 55 years were studied.

Most frequent shape of sella turcica has been found to be oval in all age groups; with a maximum of 61.6% in 26-40 years age group. However the incidence of round sella was significantly higher in the elderly age groups.

Thus, from the present study, different shapes of sella turcica were obtained from normal radiographs of Maharastrian subjects. Careful study of the shapes can be used in radiological detection of pituitary tumours, suprasellar or parasellar tumours etc. Thus this study presents comprehensive data about shape of sella turcica. The normal shape can be used as

reference values for evaluating various pathological (clinical) conditions related to sella turcica in Maharastrian population.

References

1. Isadore Meschan. An Atlas of Anatomy Basic to Radiology; W B Saunders, Philadelphia, 1975; 343–348.
2. A. Carey Carpenter. A discussion of the fascinating histories behind the words used in human anatomy. [cited Online]. www.Anatomyalmanac.blogspot.com
3. Schuller A.: The sella turcica, American journal of roentgenol, 1926; 16:336–340.
4. M. Andredaki, A. Koumantanou, D. Dorotheou and D. J. Halazonetis. A cephalometric morphometric study of the sella turcica. The European Journal of Orthodontics, 2007; 29(5):449-456.
5. Taveras J.M. and Wood E.H. Diagnostic Radiology. Second edition. The Williams Wilkins Company, Baltimore, 1976; 1:65-90.
6. GORDON, M. B. & BELL, A. L. L. A Roentgenographic study of the sella turcica in normal children. N.Y. St. J. Med. (1921); 22:54-58.
7. Enfield C. D. The normal sella J Amer. Med. Ass. (1922); 79:934-935.
8. Karl Kornblum and L. H. Osmond. Deformation of sella turcica by tumors in the pituitary fossa.Annals of Surg. (1935); 101(1):201-211.
9. Haas LL. The size of the sella turcica by age and sex. American Journal of Roentgenology, Radium Therapy and Nuclear Medicine (1954); 72:754–761.
10. Eugene P. Pendergrass, J Parsons Schaeffer and Philip J. Hodes. Head and Neck in Roentgen diagnosis.1956; 2:924-952.
11. Jupe M.H. and Northfield D. W. C. In text-book of X-ray Diagnosis by British Authors, Ed. Shanks and kerley. London: Lewis. 1956; 50-51.
12. Mahmood M. E. S. British journal of Radiology. 1958; 8:51. [Quoted by Bhargava et al.(1978)].
13. Khanna S.R. A New standard for the size of pituitary fossa. Indian journal of radiology. 1962; 16(1):25-28.
14. B. N. Lal, P. N. Tondon, S. K. Ghosh and G. N. Agrawal. Radiological study of normal sella turcica. Indian journal of Radiology 1965; 19(29):84-90.
15. G. N. Agrawal, G. B. Newton (1968) Radiologiacal Study of Normal Sella Turcica in Indians. Journal Indian M.A., 1968; 51(7):519-522.
16. Fitzerald D. P. The pituitary fossa and certain skull measurements. J. Anat. Physiol. 1910; 44(3):231-233
17. Camp J. D. Normal and pathological anatomy of the sella turcica as revealed by necropsy. Radiology 1923; 1:65-73.
18. Jones R M, Faqir A, Millet D T, Mous K F, Mc Hugh S. Bridging and dimensions of sella turcica in subjects treated by surgical orthodontics means or orthodontics only. Angle Orthod. 2004; 75:714-718.
19. A. D. Zagga, H. Ahmed, A. A. Tadros and S. A. Saidu. Description of the Normal Variants of the Anatomical Shapes of the Sella Turcica Using Plain Radiographs: Experience from Sokoto, Northwestern Nigeria. Annals of African Medicine. 2008; 7(2):77-81.
20. Heublein G.W. American journal of Roentgenol. (1946); 56(3):299.
21. Bhargava S.K. and Vijay Pal. Radiological study of Normal Sella Turcica in Indians. Indian journal of Radiol. 1978; 32:275-277.

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A Study of Embryological Basis of Variations of Renal Vessels

Suma Dnyanesh*, Dnyanesh D.K., Daksha Dixit***, S.P. Desai*****

Abstract

Kidneys are supplied by a pair of renal arteries which arise from abdominal aorta and branches laterally below the superior mesenteric artery. A single renal artery arising from aorta supplying the corresponding kidney is actually seen in less than 25% of cases. Kidneys are drained by pair renal veins into inferior vena cava. Variations in the number and branching pattern of renal vessels are common. Persistence of lateral splanchnic arteries is the main reason for variation in the number of renal arteries. The different fate of right and left subcardinal and supracardinal anastomosis is responsible for the presence of supernumerary renal veins. *Aims and objectives:* To study the anomalous pattern of renal vessels and its clinical implications. *Materials and methods:* We studied 100 cadavers over a period of 3 years for the presence of anomalies of renal vessels. *Results:* We found 3 cases of double renal arteries all on left side; 2 cases of double renal veins on right side; 1 case of pre-hilar division of renal artery. We also found 2 unusual variations: in the 1st case, inferior phrenic artery arose from right renal artery; in the 2nd case testicular artery arose from left renal artery. *Conclusion:* Variations in renal vessels can go unnoticed many times and can give rise to a number of clinical manifestations. A thorough knowledge of renal vessels is thus important for radiologic, diagnostic, operative and endovascular procedures.

Keywords: Renal Artery; Renal Vein; Lateral Splanchnic Artery; Abdominal Aorta; Inferior Vena Cava.

Introduction

Kidneys are supplied by a pair of renal arteries which arise from aorta and passes laterally below the superior mesenteric artery at the level of L_1. Right renal artery is longer and higher than the left. Usually each kidney is supplied by 1 renal artery which divides into 5 segmental branches close to the hilum [1]. Different nomenclatures have been used to describe additional renal arteries as aberrant, supernumerary, multiple, accessory, etc. According to Graves, any artery arising from aorta supplying the kidney in addition to main renal artery should be named as 'accessory' renal artery. An artery arising from other source apart from aorta is labeled as 'aberrant' renal artery [2].

Kidneys are drained by a pair of renal veins into IVC. The left renal vein is generally longer of the 2 because IVC is situated on the right side of the body [1]. The right renal vein rarely receives tributaries, whereas left renal vein regularly has complex connections with other venous channels and usually receives left gonadal vein, left suprarenal vein and left inferior phrenic vein.

Embryological Basis [3, 4]

Variations of renal and gonadal vessels have an embryological basis. According to Felix, nine pairs of lateral splanchnic arteries arising from the dorsal aorta are divided into 3 groups viz: the cranial, middle and caudal group which supply developing mesonephros, metanephros, suprarenal glands and gonads. The middle group gives rise to the renal arteries. The variation in the number of renal arteries

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is because of persistence of more than 1 artery of the middle group [3] or due to persistence of blood supply from lower level than normal [4]. Gonadal arteries can arise from any of these 9 splanchnic arteries though they usually arise from the caudal group [5]. In the present case, the origin of the left testicular artery from lower renal artery suggests the embryologic origin of this vessel from the middle group.

During development of inferior vena cava, a circum aortic venous ring, the "renal collar" is formed which is contributed mainly by subcardinal veins, inter subcardinal anastomosis, supracardinal veins and inter supracardinal anastomosis [6]. The different fate of right and left subcardinal and supracardinal anastomosis is responsible for the presence of supernumerary renal veins. On the right side, the anastomosis between subcardinal and supracardinal veins is incorporated in the development of IVC which may be the reason for persistence of primitive veins resulting in multiple veins on that side, while on the left side, the anastomosis between subcardinal and supracardinal veins completely disappears.

Materials and Methods

We studied 100 cadavers over a period of 3 years for the presence of anomalies of renal vessels.

Case 1: In a 55 years male cadaver, on the left side, the kidney was supplied by 2 renal arteries. The upper renal artery (URA) was larger than the lower. Both arteries were arising from the aorta; the gap between the 2 being 0.3 mm. The upper renal artery divided into segmental branches. The lower renal artery (LRA) entered into the kidney without dividing into segmental branches. In addition the lower renal artery gave off left testicular artery which is unusually torturous in its course. The left testicular vein drained into left renal vein.

Case 2, 3 & 4: Accessory renal arteries were found in 3 more cases (1.5%) all on left side.

In 1 male cadaver aged 60 years we got 2 renal arteries arising from the aorta on the left side with a gap of 0.2 mm. The upper renal artery entered into the kidney without dividing into segmental branches. The lower renal artery entered into the kidney by dividing into segmental branches (double RA2).

In a male cadaver aged 45 years, we found 2 renal arteries arising from the aorta: 1 was arising above the level of left renal vein and the other was arising below it with a gap of 1.2 cm (DRA 1a).

In another male cadaver, the left kidney was supplied by 2 renal arteries. Both arteries were arising from the aorta; the gap between them being 0.3 mm. (Doublera).

Case 5: While dissecting a middle aged male cadaver, we got inferior phrenic artery arising from right renal artery and it was unusually torturous in its course. It also gave a branch to the suprarenal gland.

Case 6: The renal artery usually divides into 5 segmental branches close to the hilum of the kidney. In this case, we got pre-hilar division right of renal artery.

Variations were Found in Renal Veins Also

Case 7: The presence of an additional renal vein draining directly into IVC was found on the right side during routine dissection of a middle-aged male cadaver. Both the renal veins were lying anterior to the renal artery and ureter. The upper vein was larger than the lower vein. The two veins were coming out from the upper and lower ends of the hilum and opened into IVC (DRV 4).

Case 8: We got 1 more case of double renal veins having a normal course, lying anterior the renal artery and ureter, on the right side draining into inferior vena cava. Both upper and lower renal veins had a normal caliber.

Results

200 specimens of human kidneys from 100 cadavers were dissected carefully and following results were found.

1. Accessory renal arteries were found in 3 cases (1.5%) all on left side.
2. Division of renal artery close to the aorta (pre-hilar division) was found in 1 case (0.5%).

Sl. No.	Renal vessel	Variations found	Left kidney	Right kidney
1.	Renal artery	Accessory renal artery arising from aorta	3 (1.5%)	0
		Prehilar division of renal artery	0	1
		Inferior phrenic artery arising from renal artery	0	1
		Testicular artery arising from renal artery	1	0
2	Renal vein	Double renal veins draining into IVC	0	2 (1%)

3. Two cases of double renal veins were seen on right side (1%).
4. Inferior phrenic artery arising from right renal artery was found in 1 case (0.5%).
5. Testicular artery arising from left renal artery was found in 1 case.

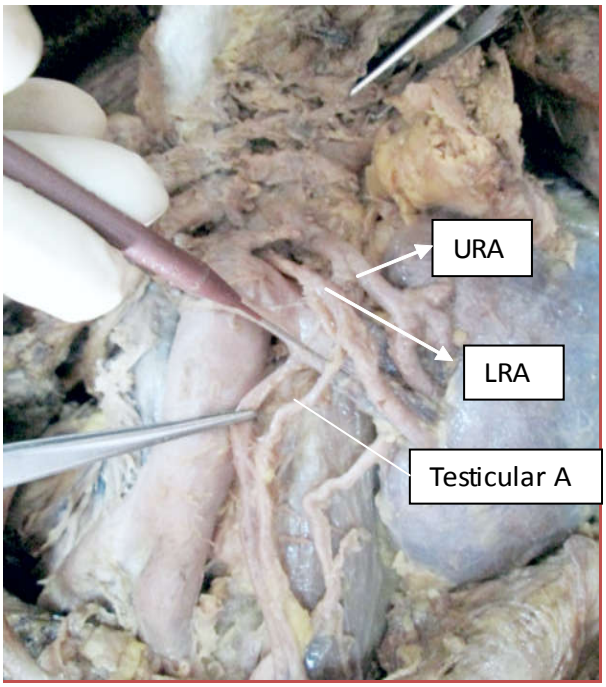

Fig. 1: Double renal arteries on left side Left testicular A arising from lower renal artery

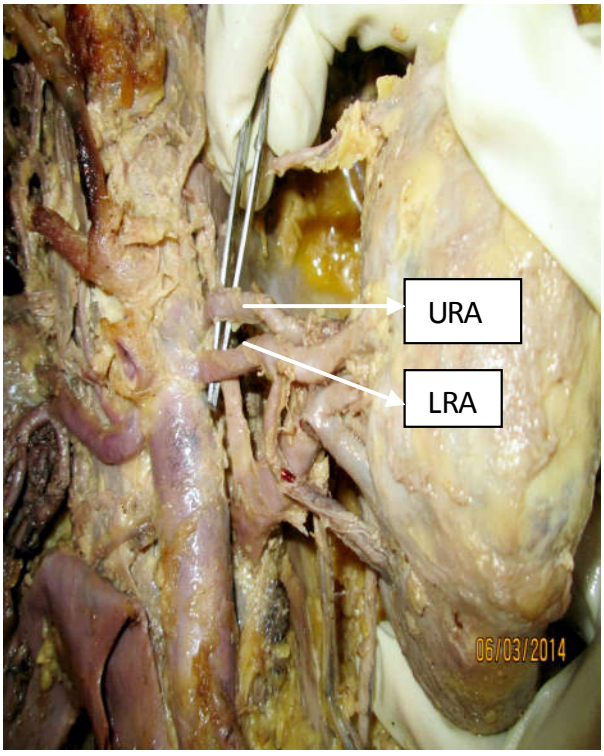

Fig. 2: Double renal arteries on left side

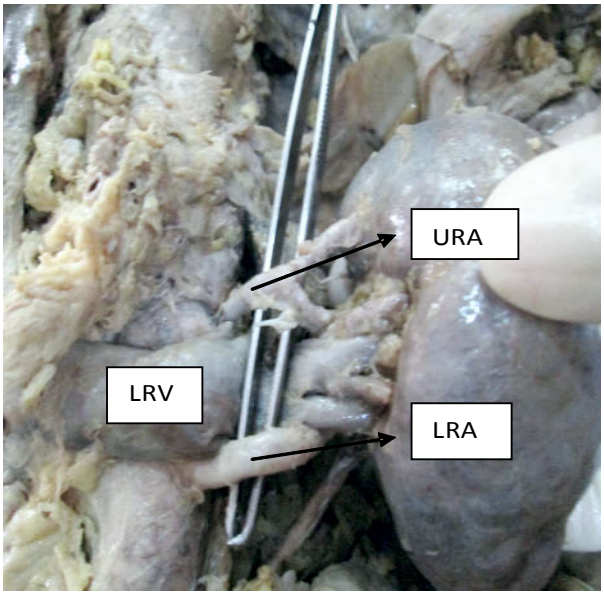

Fig 3: Double renal arteries on left side

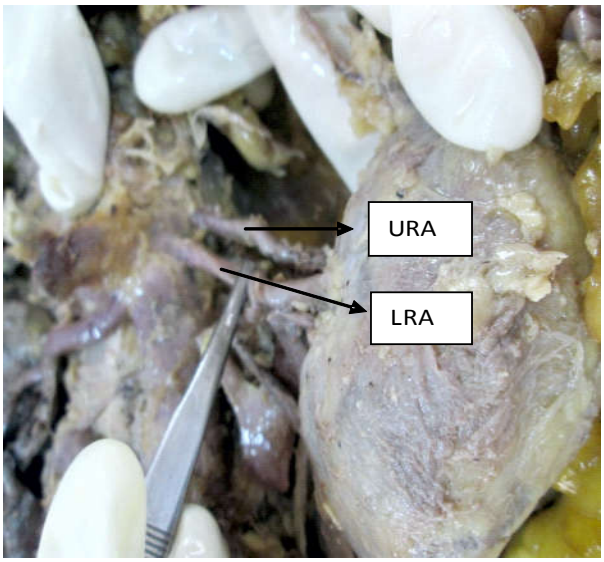

Fig. 4: Double renal arteries on left side

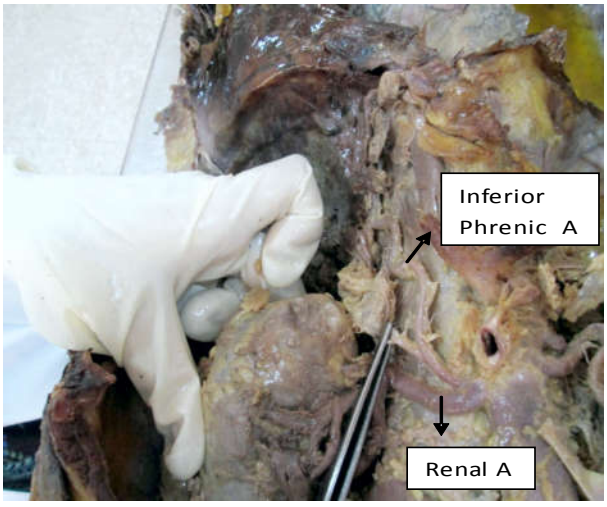

Fig. 5: Inferior phrenic A arising from right renal A

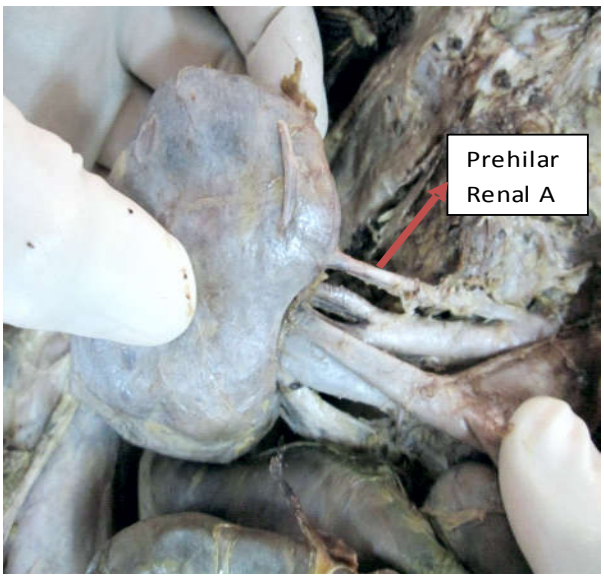

Fig. 6: Prehilar division of Renal A

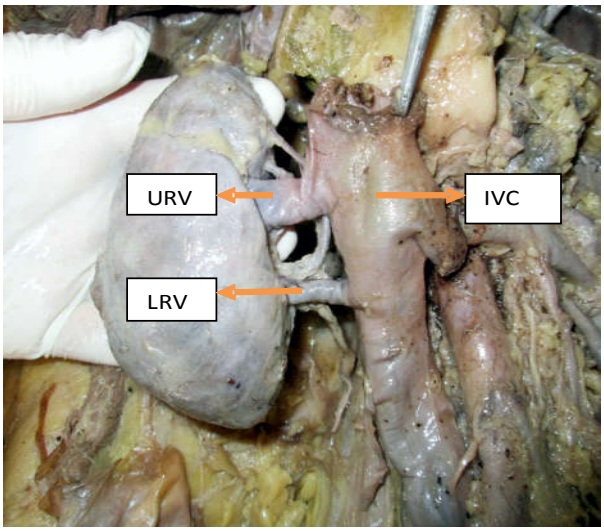

Fig. 7: Double renal veins on right side

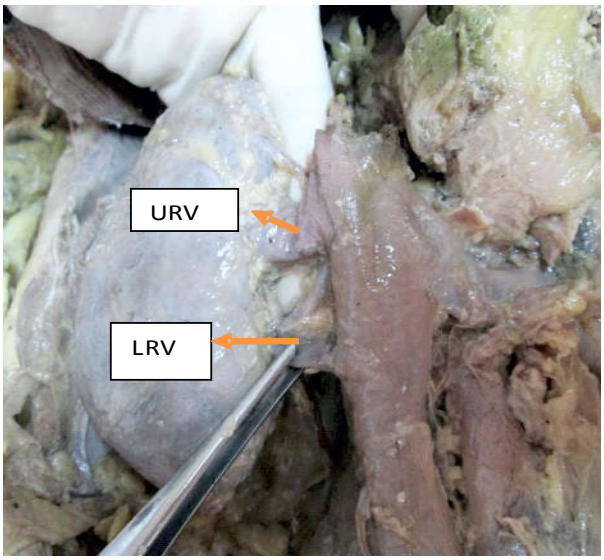

Fig. 8: Double renal veins on right side

Discussion

The permanent kidney or metanephros develops between the sixth and ninth week of intrauterine life within the pelvis and ascends to the lumbar level following a path on either side of the dorsal aorta. The ascending kidney is progressively revascularised by a series of arterial sprouts from the dorsal aorta, and the arteries at lower levels gradually regress. Occasionally one or more of the transient renal arteries at lower levels fail to regress resulting in the presence of accessory renal arteries. Thus accessory arteries are normal segmental arteries with more proximal origin than usual [4]. Previous studies have shown the origin of accessory renal arteries from aorta and the renal artery [7, 8]. In this study all the accessory arteries were arising from the abdominal aorta. Variations regarding the side on which the additional renal arteries were seen was also reported. Some authors have reported a higher frequency on the left [9], where as others have found it to be more frequent on the right side [10]. In the present study, all accessory renal arteries were found on left side.

Presence of additional renal vein has been reported to occur in 14% cases [11]. According to Satyapal there is 10 fold increase in the number of additional renal vein on the right side as compared to the left side. Satayapal also reported that incidence of additional right renal vein was 26% as compared to 2.6% on the left side [12], while Pick & Anson reported 27.8% additional veins on right side [13]. Pollak et al also observed that additional renal veins and other venous variations are more common on the right side [14]. In the present study also the same observation were seen. Additional renal vein may act as an alternate collateral route if the inferior vena cava has been interrupted between these veins [15].

We have come across an anomalous origin of right testicular artery from right accessory renal artery. Testicular arteries are paired vessels that usually arise from the antero-lateral surface of the abdominal aorta at the level of L2 (1). 4.7-14% of gonadal arteries arise from the renal arteries as reported by Asala et al., In their study of 150 cadavers, Asala et al found testicular arterial variations only on the right side (4.7%). In 4 (2.6%) of these cases, testicular arteries branched from the renal artery [16].

Conclusion

Though aberrant renal vasculature may remain undiagnosed throughout life, they could give a

formidable challenge during aortic reconstruction surgery for aorto- femoral aneurysms and post - renal aortic aneurysms. Therefore pre-operative radiological imaging is required to know the uncertain anatomy of aberrant renal vessels to minimize the risk of peri operative and post operative haemorrhage.

References

1. Dutta AK. Essentials of Human Anatomy (Thorax and Abdomen) 7th ed. Kolkatta: Current books international; 2006.p.140.
2. Graves FT. The aberrant renal artery. J. Anat. 1956; 90:553-568.
3. Felix W. Mesonephric arteries. Manual of Human Embryology. Philadelphia, Lippincott. 1912; 2:820-825.
4. Willium J Larsen. Development of urogenital system. Human Embryology. 3rd ed. Churchill Livingstone, London. 1993.p. 245.
5. Shoja MM, Tubbs RS, Shakeri AB, Oakes WJ. Origin of the gonadal artery: embryological implications. Clin Anat. 2007; 20:428-32.
6. Williams et al: Gray's Anatomy,. In: Embryology and Development, 38th Edn; Churchill Livingstone, London, 1995.p.324-326.
7. Talovic E, Kulenovic A,VolijevicaA,KapurE. Review of the supernumerary renal arteries by dissection method. Acta Medica Academica. 2007; 36:59-69.
8. Budhiraja V, Rastogi R, Anjankar V, Ramesh Babu CS, Goel P. Supernumerary Renal Arteries and their Embryological and Clinical Correlation: A Cadaveric Study. ISRN Anatomy volume 2013, Article ID 405712 ;http://dx.doi.org/10.5402/2013/405712.
9. Satyapal KS, Haffejee AA, Singh B, Ramsaroop L, Robbs JV, Kalideen JM. Additional renal arteries: incidence and morphometry. Surgradiol Anat. 2001; 23:33-38.
10. Khamanarong K, Prachany P, Tong-un T, Sripaoroya K. Anatomy of renal arterial supply. Clin Anat. 2004; 17:334-336.
11. Rupert, R.R. Further study of irregular kidney vessels as found in one hundred cadavers. Surg. Gynaecol. Obstet. 1915; 21:471-480
12. Satyapal, K.S. Additional renal vein: incidence and morphometry. Clinical Anatomy. 1995; 8:5-55
13. Pick, J. W. and Anson. Inferior Phrenic Artery: origin and suprarenal branches. Anat. Rec. 1940; 78:413-427.
14. Pollack, R, Prusak BF and Mozes MF. Anatomic abnormalities of cadaver kidneys procured for purpose of transplantation. Am. Surgeon. 1986; 52: 233-235.
15. Greweldinger, J, Coomaraswamy R, Luftchin S, Bosnaik MA. Collateral circulation through kidney after inferior vena cava ligation. N. England. J.Med. 1969; 258:541-542.
16. Asala S, Chaudhary SC, Masumbuko-Kahamba N, Bidmos M. Anatomical variations in the human testicular blood vessels. Ann Anat. 2001; 183:545–549.

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Cadaveric Study on Papillary Muscles of Human Tricuspid Valve

Kirti Chaudhary*, Monalisa Roy, Mahesh Shinde*****

Abstract

Papillary muscles are the part of the myocardium and plays an important role in valve function by drawing atrioventricular valve annulus towards apex thus preventing ventricular overextension. The aim of the present study is to find out the variations in the number of papillary muscles of right ventricle and its statistical difference between males and females. The material for the present study comprised of 50 formalin fixed adult human hearts (35 males and 15 females) without macroscopic pathological changes, obtained from different medical colleges in Maharashtra. The number of the papillary muscles varies from two to six. Anterior and posterior papillary muscles were constantly present in all hearts but septal papillary muscle was absent in 24% samples. No statistical significance was observed between males and females. The left atrioventricular valve had been largely studied. The number of papillary muscles of right ventricle varies considerably. Damage to papillary muscles may occur after trauma and further even lead to death. Knowledge regarding variability of papillary muscles will help cardiac surgeons during their corrective procedures.

Keywords: Papillary Muscles; Variations.

Introduction

There are two major and one minor papillary muscles in the right ventricle. The major papillary muscles are located in the anterior and posterior positions. The minor papillary muscle has a medial position along with several smaller and variable muscles attached to the ventricular septum.

Major Papillary Muscles

- Anterior papillary muscle: It is the largest muscle, arising from the right anterolateral ventricular wall below the antero-inferior commissure of the inferior leaflet and it also blends with the right end of the septomarginal trabecula.
- Posterior papillary muscle: The posterior or inferior muscle arises from the myocardium below the inferoseptal commissure. It is frequently bifid or trifid. It is irregular in size and position.

Minor or Septal Papillary Muscle

Is small but typical, and arises from the posterior septal limb of the septomarginal trabeculae. It is often formed of several muscles of which one may be longer and more constant.

All the major papillary muscles supply chordae to adjacent components of the leaflets they support. A feature of the right ventricle is that the septal leaflet is tethered by individual chordae tendineae directly to the ventricular septum. Such septal insertions are never seen in the left ventricle. When closed, the three leaflets fit snugly together, the pattern of the zones of apposition confirming the trifoliate arrangement of the tricuspid valve.

The papillary muscles project from the ventricular walls and are roughly conical in shape with a rounded end. They keep the atrioventricular valves closed when the ventricles contract and prevents the

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blood from flowing back into the atria. The leaflets of the valves are connected to the papillary muscles by the chordae tendineae. Most chordae tendineae arise from the tip of the papillary muscles, but some also arise from near the base. The papillary muscles contract a fraction earlier than the ventricle itself in order to prevent the valves from being forced open by the rising pressure in the ventricle. Victor and Nayak observed, after studying 100 normal human hearts, that numerous variations are present in the configuration of the cusp tissue and chordal/ papillary support of the ventricular wall and these made the interior of the ventricle as unique to each individual as one's finger print [1].

Variations in the number, shape and position of papillary muscles of right ventricle has been studied by many workers [2,3]. Congenital variations are known to be potential candidates for mechanical trauma leading to tricuspid valve lesions [4,5]. Damage to papillary muscles may occur after a trauma affecting valve function and functional capacity of body. Also the number, length and shape of papillary muscles are variable. Papillary muscles are of clinical significance as they play an important role in contraction of right ventricle and closure of tricuspid valve to prevent ventricular blood from passing back into the right atrium [6]. Also acute papillary muscle rupture secondary to myocardial infarction leads to cardiogenic shock and survival depends largely on the early surgical repair. We studied this topic as anatomical studies on papillary muscles are rare.

Materials and Methods

The material for the present study comprised of 50 formalin fixed adult human hearts which were obtained from the department of anatomy from various medical colleges in Maharashtra. The hearts with macroscopic developmental failures or pathological changes were eliminated from the study. The hearts were grouped into two groups, 35 males and 15 females.

To open the right ventricle, cut was taken from the opening of inferior vena cava and then along the right margin of the right ventricle. The tricuspid valve was cut between the anterior and posterior leaflets. The section passed near the antero-posterior commissure of the tricuspid valve to avoid damage to papillary muscles. Hearts were washed in tap water to remove blood clots. Finally results were analysed statistically. Student's t test for two independent variables was used to determine the statistical significance of gender difference.

Result

The total number of papillary muscles in the right ventricle varies from two to six. The anterior papillary muscle was single in 72%, double in 26% and triple in 2% of right ventricles. The posterior papillary muscle was single in 54%, double in 36% and triple in 10% of right ventricles. The septal papillary muscle was absent in 24% of right ventricles. It was single in 56%, double in 12% and triple in 8% of right ventricles (Table 1). The mean value of anterior papillary muscle was 1.34 in males and 1.20 in females. The mean value of posterior papillary muscle was 1.51 in males and 1.67 in females. The mean value of septal papillary muscle was 1.40 in males and 1.33 in females. The standard deviation for anterior, posterior and septal papillary muscles was 0.54, 0.66 and 0.71 respectively in males. The standard deviation for anterior, posterior and septal papillary muscles in females was 0.41, 0.72 and 0.65 respectively. No statistical significance was found for the number of anterior, posterior and septal papillary muscles between males and females (p value>0.05) (Table 2).

Table 1: Showing frequency of anterior, posterior and septal papillary muscles in rightventricleof adult human hearts (male and female combined)

Papillary muscle	Number of papillary muscles				
	Single	Double	Triple	Absent	Total (No. of Sample)
Anterior	36	13	1	-	50
Posterior	27	18	5	-	50
Septal	28	6	4	12	50

Table 2: Comparison of number of papillary muscles of right ventricle between males and females

Sr. No.	Papillary Muscles	Male		Female		Statistical Significance
		Mean	S.D.	Mean	S.D.	
1.	Anterior	1.34	0.54	1.20	0.41	Not significant
2.	Posterior	1.51	0.66	1.67	0.72	Not significant
3.	Septal	1.40	0.71	1.33	0.65	Not significant

S.D.-standard deviation

Table 3: Comparison of incidence of papillary muscles in percentage

Sr. No.	Studies	Sample size	APM	PPM	SPM
1.	Wafae N et al	50	100	100	100
2.	Gerola LR et al	50	100	84	100
3.	Nigri GR et al	50	100	100	78.5
4.	Motabagani MAB	10	100	100	100
5.	Begum et al	50	92	60	76
6.	Harsha BR	96	100	100	95.8
7.	Present Study	50	100	100	76

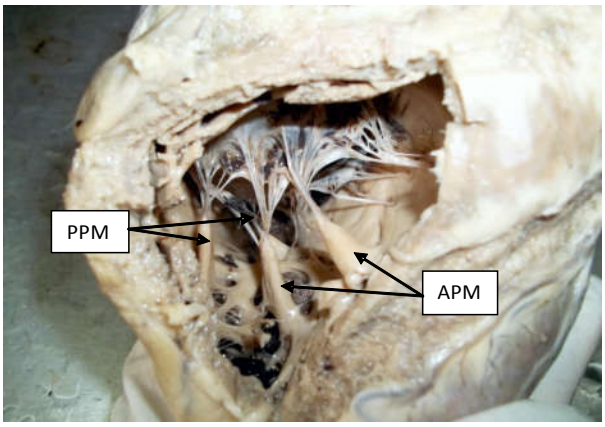

Fig. 1: Interior of right ventricle showing numerous anterior papillary muscles (APM) and posterior papillary muscles (PPM) of human heart

Discussion

Papillary muscle is vulnerable to ischemia as it is a subendocardial structure, supplied by terminal branches of the coronary arteries and develop large amount of tension during ventricular systole. Developmental defect of papillary muscle apparatus such as congenitally long or short papillary muscles or chordae tendineae, ectopic origin of papillary muscles and ectopic insertion of chordae tendineae result in papillary muscle dysfunction. Endocardial disease, heart muscle disease or infiltrative diseases may cause disturbances in the time course of papillary muscle activation and contraction resulting in papillary muscle dysfunction.

In the studies conducted by Wafae N et al and Motabagani MAB, all the three types of papillary muscles were observed in human hearts [7,8]. Gerola LR et al observed anterior and posterior papillary muscles in all the hearts, while septal papillary muscles were absent in 16% samples [9]. In the study of Begum et al on 50 human hearts, anterior papillary muscles were present in 92% hearts, posterior papillary muscles were present in 60% hearts while septal papillary muscles were absent in 24% samples also no statistical significance was observed between males and females [10]. Nigri GR et al and Harsha BR observed the presence of anterior and posterior papillary muscles in all the samples while septal papillary muscles were absent in some hearts [3]. The findings of present study was in agreement with the work of Nigri GR et al and Harsha BR. From all the studies it is observed that anterior and posterior papillary muscles are constantly present while septal papillary muscle can be absent many times (Table 3).

Aktas et al conducted the study comprised of 400 human hearts and observed that the papillary muscle presented great variability in numbers. The one headed anterior papillary muscle was found to be more often in cardiac deaths. They observed more frequent conical and flat topped configurations in all posterior papillary muscle [12]. Skwarek distinguished the "conal papillary muscle" and the "papillary muscle of the posterior angle of the right ventricle" [13]. Skwarek performed a study on a group of 107 formalin-fixed adult human hearts and observed three types of connection of the tricuspid valve to the papillary muscles. Type 1 — A straight connection, Type 2 A membranous connection and Type 3 A connection by means of tendinous cords [14].

Systemic circulatory disturbances as hypotension, anoxia etc. may led to circulatory insufficiency (ischaemia) resulting in acute and chronic infarction (fibrosis) of papillary muscle. Generalized or localized ventricular aneurysm or dilatation may result in papillary muscle dysfunction. Non ischemic atrophy of papillary muscle associated with cachexia may result in dysfunction of papillary muscles. Rupture of papillary muscle or chordae tendineae and coronary insufficiency are the common causes for papillary muscle dysfunction. Newer surgical techniques like commissurotomy and papillotomy in rheumatic lesions, excision of infective vegetation, rotation and transfer of leaflet segments in traumatic conditions and correction of papillary rupture induced Tricuspid regurgitation requires knowledge regarding anatomical variations of papillary muscles. Knowledge of a detailed morphology of papillary muscle is necessary for cardiothoracic surgeries because abnormally short and thick tendinous chords and papillary muscles can complicate the congenital anomalies like Ebstein's malformations, dysplasia or straddling [15].

Conclusion

In the present study, number of papillary muscles varies from two to six in the right ventricle of the human heart and no statistical significance was found between males and females. Number of papillary muscles and the number of cords attached to leaflets are important with the rapid progress in the field of interventional cardiology and the introduction into cardiosurgery of new valvuloplastic methods. Therefore this study will help cardiac surgeons in providing a data for papillary muscles during correction of their defects. It will help clinicians to appreciate valvular anomalies during imaging and also in deciding their diagnosis and treatment.

References

1. Victor S, Nayak VM. The tricuspid valve is bicuspid. J Heart Valve Dis. 1994; 3(1):27-36.
2. Bardy GH, Talano JV, Meyers S, Lesch M. Acquired cyanotic heart disease secondary to traumatic tricuspid regurgitation:Case report with a review of the literature.Am J Cardiol. 1979; 44:1401-6.
3. Nigri GR, Di Dio LJ, Baptista CA. Papillary muscles and tendinous cords of the right ventricle of the human heart:morphological characteristics. Surg Radiol Anat. 2001; 23:45-9.
4. Chares M, Lamm P, Leischik R, Lenz G, Steinmann EH, Polonius MJ. Highly acute course of ruptured papillary muscle of the tricuspid valve in a case of blunt chest trauma. Thorac Cardiovasc Surg. 1993; 41:325-7.
5. Hachiro Y, Sugimoto S, Takagi N, Osawa H, Morishita K, Abe T. Native valve salvage for post traumatic tricuspid regurgitation. J Heart Valve Dis. 2001; 10:276-8.
6. Xanthos T, Dalivigkas I, Ekmektzoglou KA. Anatomic variations of the cardiac valves and papillary muscles of the right heart. Italian Journal of Anatomy and Embryology. 2011; 116(2):111-26.
7. Wafae N, Hayashi H, Gerola LR, Vieira MC. Anatomical study of the human tricuspid valve. Surg Radiol Anat. 1990; 12(1):37-41.
8. Motabagani MAB.Comparative Anatomical, Morphometric and Histological Studies of the Tricuspid Valve-Complex in Human and Some Mammalian Hearts. J Anat Soc India. 2006; 55(1):1-23.
9. Gerola LR, Wafae N, Vieira MC, Juliano Y, Smith R, Prates JC. Anatomic study of the tricuspid valve in children. Surg Radiol Anat. 2001; 23(3):149-53.
10. Begum JA, Khalil M, Rahman H, Adiluzzaman AA.A morphological and morphometric study of the right ventricular papillary muscles of autopsied heart of Bangladeshi people. Mymensingh Med J. 2006 Jul; 15(2):131-4.
11. Harsha BR, Chandrashekar KT.Cadaveric study on anterior and posterior papillary muscles of tricuspid valve.Int J Anat Res. 2015; 3(1):865-8.
12. Aktas EO, Govsa F, Kocak A, Boydak B, Yavuz I. Variations in the papillary muscles of normal tricuspid valve and their clinical relevance in medicolegal autopsies. Saudi Medical Journal. 2004; (9):1176-85.
13. Skwarek M, Hreczecha J, Grzybiak M, Kosiñski A. Remarks on the morphology of the papillary muscles of the right ventricle. Folia Morphol (Warsz). 2005; 64(3):176-82.
14. Skwarek M, Dudziak M, Hreczecha J, Grzybiak M. The connection between the papillary muscles and the leaflets of the tricuspid valve. Folia Morphol. 2006; 65:322–8.
15. Joudinaud TM, Flecher EM, Duran CMG. Functional terminology for the Tricuspid valve. J Hear Valve Dis. 2006 May; 15(3):382-8.

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Morphometric and Topographic Study of Nutrient Foramina of Fibula

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Abstract

Introduction: The study on morphology of nutrient foramina of fibula can provide prudent information for various bone grafting orthopedic surgeries. The present study was undertaken to generate morphometric and topographic data of fibula from western India, where there is paucity of such information. *Materials and methods:* This study included 140 specimens of dry human fibulae devoid of gross pathological deformities, obtained from department of Anatomy of four medical colleges in Mumbai (Topiwala National Medical College, Seth GS Medical College, Lokmanya Tilak Medical College and Government Medical College, Mumbai). All fibulae were observed for number, direction and location of the nutrient foramina. The position of foramina was labeled by using foraminal index (FI) which was calculated by applying the Hughes' formula. *Results:* Nutrient foramina were traceable in 125 (89.29%) fibulae. Dominant and secondary nutrient foramina was present in 121 (86.43%) and 10 (7.14%) fibulae respectively. 110 (88.71%) dominant foramina were in lower direction. Most of the foramina were present on the posterior surface. Dominant and secondary nutrient foramina were present on middle of shaft of fibulae in 91.12% and 50% of cases respectively. *Conclusion:* The present study confirms and compares the morphometric and topographic data on fibula from western part of India.

Keywords: Fibula; Foraminal Index; Nutrient Foramina.

Introduction

Bone grafts are frequently used in all specialties of orthopaedic surgery. Bone grafts and bone graft substitutes have a number of innate properties which permit them to initiate, stimulate, and facilitate bony healing. Osteoconduction is the process by which the graft provides a scaffold for the ordered 3-D ingrowth of capillaries, perivascular tissue, and osteoprogenitor cells. Osteoinduction is the recruitment of osteoprogenitor cells from surrounding tissue. Osteogenesis is the formation of new bone from either the host or graft tissue. Autogenous and allogenic cortical and cancellous bone grafts are all, to varying degrees, osteoconductive, osteoinductive, and osteogenic [1]. Bone grafts thus play a vital role in orthopedic surgeries.

Fibular grafting is a widespread procedure in orthopedic practice [2]. Biomechanically, the fibula bears only 15 percent of the axial load across the ankle, allowing for its use as an autogenous bone graft with minimal biomechanical consequences on the weight-bearing status of the lower limb. Given the length of fibular diaphysis that may be harvested, free fibular grafts are well suited for the reconstruction of segmental defects of the long bones, providing both mechanical strength and biological stimulus for healing. Furthermore, based upon the fasciocutaneous arterial branches of the peroneal artery, skin, fascia, and muscle may be harvested concomitantly with the fibula to allow for more complex soft tissue reconstruction. Finally, given the ability to transfer the proximal fibular epiphysis with the diaphysis during free vascularized fibular grafting, there is potential for preserving continued

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skeletal growth of the fibular graft [3].

The study on morphology of nutrient foramina of fibula can provide prudent information for various bone grafting orthopedic surgeries. This kind of information is available from different parts of India. The present study was an effort to generate similar data from western India, where there is paucity of such information. The study data also provides the opportunity for analyzing the variation in morphological parameters of fibular nutrient foramina across different parts of India.

Materials & Methods

This morphometric and topographic study was conducted in the department of Anatomy of four medical colleges in Mumbai (Topiwala National Medical College, Seth GS Medical College, Lokmanya Tilak Medical College and Government Medical College, Mumbai). This study included 140 specimens of dry human fibulae devoid of gross pathological deformities (87 right, 53 left sided).

All fibulae were observed for number, direction and location of the nutrient foramina. The distance of nutrient foramina from the proximal end and total fibular length was noted with the help of Vernier's Calipers.

The age and gender of bones were not determined in this study.

A magnifying lens was used to observe the nutrient foramina. The nutrient foramina were identified by the presence of a well marked groove leading them and a well marked, often slightly raised, edge at the commencement of the canal. Nutrient foramina were labeled as primary or dominant (DF) if diameter of the foramina was equal or more than the size of 24 g hypodermic needle (0.56 mm) (checked by inserting 24 g hypodermic needle; if able to insert, size of foramina was considered to be 0.56 mm or greater).Those smaller than the size of 24 g hypodermic needle were considered as secondary nutrient foramina (SF) [4].

Direction of nutrient foramina was confirmed with the help of a thin probe.

The side determination was done for the fibulae and thus surface for presence of nutrient foramina was confirmed accordingly.

The position of foramina was labeled by using foraminal index (FI) which was calculated by applying the Hughes formula i.e., dividing the distance of the foramen from the proximal end (D) by the total length of the bone (L) which was multiplied by hundred. [FI = D / L x 100].

Subdivisions of foraminal position according to foraminal index (FI):

The positions of the foramina were grouped into three types according to FI as below:

Type 1: FI from 01 up to 33.33- The foramen is in the proximal third of the bone.

Type 2: FI from 33.34 up to 66.66- The foramen is in the middle third of the bone.

Type 3: FI 66.67 & above - The foramen is in the distal third of the bone.

Results

140 fibulae were observed which included 87 right and 53 left sided.

Number of Nutrient Foramina

Nutrient foramina were traceable in 125 (89.29%) fibulae, while 15 (10.71%) had absentia of any nutrient foramina. 9 (6.43%) fibulae had both dominant and secondary nutrient foramina.

Dominant and secondary nutrient foramina was present in 121 (86.43%) and 10 (7.14%) fibulae respectively. 115 (82.14%) fibulae had exclusive presence of dominant nutrient foramen. 4 (2.86%) fibulae were exclusively supplied through secondary nutrient foramen.

Two fibulae had presence of multiple dominant foramina (2 & 3 dominant foramina respectively). Multiple secondary foramina were observed in 3 fibulae (Two fibulae with 2 & one fibulae with 4 secondary foramina respectively).

Total 142 nutrient foramina were found, 124 (87.32%) being dominant foramina and 18 (12.68%) secondary foramina.

Direction of Nutrient Foramina

110 (88.71%) dominant foramina were in lower direction i.e., away from the growing end. Number of secondary foramina directed in lower and upper end were almost equal, 8 (44.44%) and 10 (55.56%) respectively (Table 1).

Location of Nutrient Foramina

97.77% dominant foramina were present on the posterior surface whereas 3.22% were on lateral

surface of fibulae. 94.44% secondary foramina were located on posterior surface with mere 5.55% on lateral surface. None of the fibulae had any primary or secondary foramina on medial surface.

Foraminal index was calculated by using Hughes formula (Table 2).

Based on the foraminal indices, dominant and secondary nutrient foramina were present on middle of shaft of fibulae in 91.12% and 50% of cases respectively (Graph 1). FI ranged from 22.83 to 73.46 for fibular nutrient foramina in this study (Table 2).

Table 1: Direction of dominant and secondary foramina

Direction	% in Upper direction (n)	% in Lower direction (n)
DF	11.29(14)	88.71(110)
SF	55.56 (10)	44.44 (8)

Table 2: Foraminal index of Fibulae

Foramina Index Parameter	Dominant Foramina	Secondary Foramina
Mean	45.42	50.62
S.D.	9.08	17.53
Min value	22.83	23.23
Max value	73.46	73.13

Table 3: Incidence of dominant, secondary and absent nutrient foramina in different studies

Study	Dominant foramina	Secondary foramina	Absent
Gumusburn et al[7]	92.14%	3.9%	3.9%
Agrawal et al[8]	82.75%	17.24%	4%
Bilodi et al[6]	85%	13%	2%
Pereira et al[9]		0.87%	
Prashanth et al[5]	90.2% [DF+SF]		9.8%
Present study	86.43%	7.14%	10.77

Table 4: Surface of fibula showing nutrient foramina in different studies

Study	PS	LS	MS	MC	IB	PB	AS
Agrawal et al[8]	22.22%	3.5%		67.25%			
Malukar et al[16]	90.8%	2.2%	6.8%				
Bilodi et al[6]	29.62%	22.23%	21.16%	8.99%	7.93%	2.11%	0.53%
Gumusburun et al[7]	48.36%	3.62%	19.40%	19.74%	0.64%	7.22%	-
Periera et al[9]	1.8	98.2					
Present study (DF)	97.7%	3.22					
Present study (SF)	94.44	5.56					

DF, dominant foramina; SF, secondary foramina; PS, posterior surface; LS, lateral surface; MS, medial surface; MC, medial crest; IB, interosseos border; PB, posterior border; AS, anterior surface

Table 5: Position of foramina on shaft of fibula based on FI in different studies

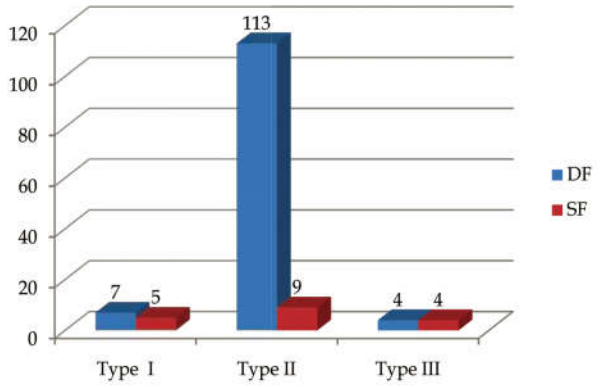
Study	Type I	Type II	Type III
Gumusburn et al[7]		98%	0.7%
Agrawal et al[4]		97.91%	2.08%
Bilodi et al[6]	29.10%	29.62%	38.62%
Malukar et al[16]	4.59%	85%	10.34%
Prashanth et al[5]	26.7%	60%	13.3%
Present study (DF)	5.66	91.13	3.23
Present study (SF)	27.78	50	22.22

FI, foraminal index; DF, dominant foramina; SF, secondary foramina

Table 6: Comparison of foraminal index in different studies

Study	Foramina Index (FI)	
	Mean ±S.D.	Range
Agrawal[4]	39.66 ± 5.29	35.92 to 68.79
Gumusburun[7]	48.13 ± 0.46	23 to 70
Pereira[9]	46.1	33.5 to 67.1
Present Study (DF)	45.42±9.08	22.83 to 73.46
Present Study (SF)	50.62±17.53	23.23 to 73.13

DF, dominant foramina; SF, secondary foramina



DF, dominant foramina; SF, secondary foramina

Graph 1: Distribution of nutrient foramina based on foraminal Index

Discussion

Presence of nutrient foramina was sighted in 89% cases from 140 fibulae. Nutrient foramina was absent in remaining 11% cases (Table 3). These findings correspond with the observations made by Prashanth et al, whereas, Bilodi et al reported just 2% fibula with absence of nutrient foramina. It has been cited that in such cases of absent nutrient foramina, the bone is supplied by periosteal vessels [5,6]. The absent foramina can be because of ossification in old age. As the age determination was not done in this study, we are unable to concretely comment on this aspect. The studies on foramina of fibula have shown the presence of dominant and secondary foramina in the range of 82-92% and 1-12% of cases (Table 3). The present study from western part of India also corresponds with the range found in the previous studies. The data shows that in majority of fibular cases, dominant or primary nutrient vessels are present while in some of the cases (6 fibulae) additional vessels through secondary foramina are also available. The study also showed presence of multiple dominant and secondary nutrient foramina in 5 fibulae. The lack of age and gender determination is a limitation in this study. Otherwise, it has been observed in previous studies that incidence of multiple nutrient foramina is high in males (15%) versus females (1%) [10].

Majority of dominant foramina in this study were directed towards lower end. Thus the finding consolidates the popular saying about direction of nutrient foramina "seek the elbow and flee from the knee" [11]. There are many theories put forward to explain the direction of normally and anomalously directed foramina. The 'periosteal slip' theory of Schwalbe and vascular theory of Hughes are widely accepted in the literature amongst these [12,13]. Patake and Mysorekar suggested that the number of foramina are not significantly related to the length of the bone [14]. It was proposed that the direction of nutrient foramina is determined by the growing end of the bone. The growing end is supposed to grow at least twice as fast as the other end [15]. The nutrient artery runs away from the growing end as the growing bone might pull and rupture the artery. So the nutrient foramina are directed away from the growing end.

The dominant as well as secondary foramina were found majorly on posterior surface of fibulae (98% & 94% respectively). As against this, study by Bilodi et al. found relatively equal distribution of nutrient foramina on posterior (29.62%), lateral (22.23%) and medial (21.16%) surfaces and predominantly on posterior surface by Agrawal et al [4,6] (Table 4).

The mean foraminal index and the range of values observed in this study correspond with the previously conducted studies by Gumusburun et al and Periera et al [7,9] (Table 5). The foraminal index has revealed the presence of foramina in middle third (Type II) of fibular shaft in most of the cases, including this study, except a relatively equal distribution along the shaft observed by Bilodi et al (29.62%, 38.62% and 29.1% respectively on upper, middle and lower thirds) (Table 6) [6]. The location of nutrient foramina of long bones may alter during growth [5]. The presence of samples from varied age groups in this study might be the reason for values of FI ranging from 22.83 to 73.46.

Conclusion

The present study confirms and compares the morphometric and topographic data on commonly used bone for grafting i.e. fibula. This data from western part of India can be considered as a useful addition of information required for various orthopedic resection and graft surgeries.

References

1. Bae DS, Waters PM. Free Vascularized Fibula Grafting: Principles, Techniques, and Applications in Pediatric Orthopaedics. Orthopaedic Journal at Harvard Medical School 2006; 6:86-89. [Cited 2016 July 16] Accessed from http://www.orthojournal hms.org/volume8/manuscripts/index.asp.
2. Mukherjee AN, Pal AK, Singharoy D, Baksi D, Nath C. Harvesting the free fibular graft: A modified approach. Indian J Orthop. 2011 Jan-Mar; 45(1): 53–56.

3. Tsai TM, Ludwig L, Tonkin M. Vascularized fibular epiphyseal transfer. A clinical study. Clin Orthop Relat Res 1986; 210:228-234.
4. Agrawal N, Tiwari A, Shrivastava SK. Study of diaphyseal dominant and secondary nutrient foramina in fibula: its clinical relevance in vascular bone graft surgery. Int J Anat Res 2015; 3(4):1471-75.
5. Prashanth KU, Murlimanju BV, Prabhu LV, Chettiar GK, Pai MM. Morphological and topographical anatomy of nutrient foramina in the lower limb long bones and its clinical importance: Australasian Medical Journal: 2011; 4(10):530-537.
6. Bilodi AS, Reddy BS. A Study On Nutrient Foramina Of Fibula, Its Medicolegal Aspect & Clinical Importance In Dentistry: World Journal Of Pharmacy And Pharmaceutical Sciences 2014; 3(2):2133-2144.
7. Gumusburun E, Adiguzele, Erdil H, Ozkan Y , Gulec E. A Study Of The Nutrient Foramina In The Shaft Of The Fibula: Okajimas Folia Anat. Jpn. 1996; 73(2-3): 125-128.
8. Agrawal N, Parmar AS. Naik DS. Correlation between number and size of nutrient foramina to bone length: An anatomical study in lower limb long bones. International Journal of Applied Research 2016; 2(3):08-11.
9. Pereira GA, Lopes, PT, Santos AM, Silveira FH. Nutrient Foramina in the Upper and Lower Limb Long Bones: Morphometric Study in Bones of Southern Brazilian Adults. Int J Morphol. 2011; 29(2):514-520.
10. Rao SV, Kothapalli J. The Diaphyseal nutrient foramina architecture-a study on the human upper and lower long limb bones. IOSR Journal of Pharmacy and Biological Sciences 2014; 9(1):36-41.
11. Ukoha U, Kosisochukwu EU,Nzeako HC, Ezejindu DN, Ejimofor OC, Izuchukwu FO. A study of nutrient foramina in long bones of Nigerians. National Journal of Medical Research 2013; 3(4):304-308.
12. Schwalbe G. Z Anat Entwicklungsgeschichte. 1876; 1:307–352.
13. Hughes H. The factors determining the direction of the canal for the nutrient artery in the long bones of mammals and birds. Acta Anat (Basel) 1952; 15:261–280.
14. Patake SM, Mysorekar VR. Diaphysial nutrient foramina in human metacarpals and metatarsals. J Anat. 1977; 124:299–304.
15. Mysorekar VR. Diaphysial nutrient foramina in human long bones. J Anat. 1967; 101:813–822.
16. Malukar O, Joshi H. Diaphysial Nutrient Foramina In Long Bones And Miniature Long Bones. NJIRM 2011; 2(2):23-26.

Original Article

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A Morphometric Study of the Proximal End of Tibia in North East Karnataka Population with Its Clinical Implication

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Abstract

Introduction: The present study aims to assess different morphometric parameters of condylar and intercondylar surface of tibia and to compile the results, analyze and formulate a baseline data for future studies with relevance to North-East Karnataka population. Total knee arthroplasty (TKA) and unicompartmental knee arthroplasty (UKA) are frequently done procedures for the treatment of various forms of arthritis and knee injuries. The knee prosthesis, which is used for these procedures, requires adequate sizing specific to the population. Hence the aim of the present study is to measure various parameters of the proximal end of the tibia in North east Karnataka population in Bidar district. *Materials and Method:* Sixty (32 Right and 28 Left) adult fully ossified tibia bone were taken and various parameters of the proximal end of tibia were measured using a vernier caliper. Statistical analysis of the parameter was done.Comparision between various parameters of right and left side was done using paired't' test. *Result:* In our study the mean transverse, the antereposterior diameter of total, medial and lateral candyles of tibia are 6.29, 4.16, 2.66, 4.08, 2.80, 3.35 cm. The area of medial, lateral and total tibial condyle is 10.86, 9.50 and 26.30 cm. The mean length between the upper end of tibia and tibia tuberosity and the mean circumference of the upper end of tibia is 2.16 and 19.11cm. Groove for ligamentum patellae is found in 100% of cases. *Conclusion:* The result of these study will be helpful for anatomist, anthropologist, to Orthopedition in cases of UKA, TKA procedures and meniscal transplantation. This study is also helpful to prepare prosthesis of accurate size related to Bidar district population.

Keywords: Tibia; Medial Condyle; Lateral Condyle; Arthroplasty; Area.

Introduction

The lower limb is primarily adapted for weight bearing and locomotion. In man weight bearing is related mainly to extended knee position. The knee joint is a compound synovial joint which brings out the significant function of adjusting the centre of body mass and posture, requiring a great range of movement in three dimensions together with the capability to bear high forces [1].

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Tibia is the medial bone of the leg. It has a shaft with two expanded ends. The proximal end of tibia, expanded especially transversely, is a bearing surface of body weight transmitted through the femur; it has massive medial and lateral condoyle, an intercondylar area and tibial tuberosity. The condoyle overhang the shaft's proximal posterior surface and both have proximal articular surfaces separated by an irregular intercondylar area. The proximal tibial surface slopes posteriorly and downwards relative to the shaft's long axis; the tilt is more marked in habitual squatters. The relationship between the different weight bearing situations and the anteroposterior and medio-lateral dimensions of diaphysis and epiphysis of the tibia is well established [2]. Information regarding morphometry of upper end of tibia is vital as it provides reliable method of assessing knee deformity. Morphometric parameters of upper end of tibia can be used to guide treatment and monitor outcome of total knee

replacement surgeries [3].

The proximal end of tibia is a crucial component of the knee joint through the tibio-femoral articulation and plays a vital role in the conduction of body weight from the femur above to the talus below. The knee joint is affected by several forms of arthritis such as inflammatory and posttraumatic arthritis and Osteoarthritis is the most common pathological disorder and the treatment for that is usually total knee arthroplasty (TKA) or unicompartmental knee arthroplasty (UKA) [4].

Total knee arthroplasty is a precision surgery, requiring accurate soft tissue balancing and resection of bone thickness equal to the thickness of the prosthetic component implanted, so that the flexion-extension spacing are equal, allowing joint stability throughout the range of motion. The success of total knee arthroplasty depends to a large extent on prosthetic selection and accurate sizing and proper placement of the components [5]. Maximum implant coverage on the resected bone surface would decrease the stess applied to the bony implant interface, which has been found to be a reason contributing to the long term survivorship in TKA [6]. Unicompartmental knee arthroplasty is presently developing as a satisfactory possibility for the treatment of unicompartmental arthritis of the knee in elderly patients [7]. Indian and Chinese, as a part of the Asian subpopulation, have a smaller build and stature compared with the Western population. It has long been suspect that, considering the large variability of the anthropometry of different populations of the world, ethnic groups such as Indians, are likely to develop technical errors in both unicompartmental knee arthroplasty and total knee arthroplasty with most of the commercially available prosthesis because of the non availability of smaller sized components [8]. There are no published studies on the anthropometry of the proximal tibia in North-East Karnataka population which may differ from different part of India; hence the results obtained from this study would provide valuable data on the average dimensions of the tibia of North-East Karnataka population which will be helpful for total knee arthroplasy and unicompartmental knee arthroplasty of this region.

Aims and Objectives of the Study

1. To measure various parameters of the proximal end of tibia.
2. To provide data for sizing of tibial component in unicompartmental knee arthroplasty and total knee arthroplasty prosthesis in North – East Karnataka population with comparison of data in different part of India.

Material and Method

Study Centre

Department of Anatomy, Bidar Institute Of Medical Sciences Bidar

Duration of the Study

6-8 months

Study Design

Cross sectional

Sample Size

The pilot study will be done in the Department of Anatomy BRIMS Bidar by taking 30 tibia of right side and 30 tibia of left side.

Inclusion Criteria

60 fully ossified and processed dry tibial bones of both sides irrespective of age sex and race.

Exclusion Criteria

Unossified bones, bones with diseases and injuries.

Data Collection and Methods

Method of collection of data is by measuring the following parameters of the proximal end of the tibia by using Vernier calliper-

1. Anteroposterior diameter of medial tibial condyle
2. Transverse diameter of medial tibial condyle
3. Anteroposterior diameter of lateral tibial condyle
4. Transverse diameter of lateral tibial condyle
5. Transverse diameter of total tibial condyle
6. Anteroposterior diameter of intercondylar region
7. Circumference of the upper end
8. Length between upper end and tibial tuberosity
9. Area total tibial condyle
10. Area medial tibial condyle
11. Area lateral tibial condyle
12. Presence or absence of groove for ligamentum patellae.

Area of the condyle is measured using following formula.

Area of condyle = AP*TD of condyle

Statistical analysis for all the parameters was done. Paired sample "t" test was done to see the statistical significance between right and left side.

Consent

Consent from professor and HOD of Department of Anatomy is taken.

Result

The mean and range of all the parameters of the right, left and total tibia is shown in Table 1. Groove for ligamentum patelle on the tibial tuberosity is present in 100% of cases. There is no statistically significant relation between right and left AP diameter of medial condyle, AP diameter of lateral condyle, transverse diameter of medial tibial condyle, transverse diameter of lateral condyle, transverse diameter of total tibial condyle, AP diameter of Intercondylar region, Circumferance of upper end of tibia, Length between upper end of tibia and tibial tuberocity, and area of total tibial condyle, medial tibial condyle lateral tibial condyle as p value is >0.05 (Table 2).

In our study the area covered by medial tibial condyle is 41.57% and by lateral condyle is 36.84% out of the total condylar area on right side. The area covered by medial tibial condyle is 40.76% and by lateral condyle is 35.38% out of the total condylar area on left side. AP diameter of medial tibial condyle in right and left tibia is 4.10±0.375 and 4.06± 0.398 respectively where as Transverse diameter of medial tibial condyle in right and left tibia is 2.69±0.271, 2.63 ±0.273 respectively, AP of lateral tibial condyle in right and left tibia is 3.43±0.355and 3.27 ±0.439 respectively whereas Transverse diameter of lateral tibial condyle is 2.86±0.335 and 2.75 ±0.355 respectively. AP diameter of intercondylar region in

Table 1: The Mean, Range and standard deviation of all the parameters of Right & left Tibia

Parameters	Mean +-SD						Range		Total
	Right	SD	Left	SD	TOTAL	SD	Right	Left	
AP Length of MTC	4.10	0.375	4.06	0.398	4.08	0.383	3.49-4.85	3.54-4.86	3.49-4.86
TD Length of MTC	2.69	0.271	2.63	0.273	2.66	0.271	2.21-3.22	2.25-3.13	2.21-3.22
AP Length of LTC	3.43	0.355	3.27	0.439	3.35	0.401	2.38-4.17	2.53-4.16	2.38-4.17
TD Length of LTC	2.86	0.335	2.75	0.355	2.80	0.346	2.22-3.44	2.22-3.34	2.22-3.44
TD Length of TTC	6.33	0.435	6.25	0.465	6.29	0.447	5.62-7.19	5.55-6.99	5.55-7.19
AP Length of TCR	4.19	0.374	4.14	0.365	4.16	0.368	3.33-4.89	3.54-4.68	3.33-4.89
Circumference of Upper end of Tibia	18.68	1.490	9.60	1.342	19.11	1.485	17.00-22.00	17.00-22.00	17.00-22.00
Length between Upper end & Tibial Tuborsity	2.68	0.376	2.65	0.513	2.66	0.441	2.12-3.65	2.12-3.75	2.12-3.75
Area of TTC	26.60	3.673	25.94	3.483	26.30	3.572	19.08-33.31	19.75-31.31	19.08-33.31
Area of MTC	11.06	1.861	10.63	1.675	10.86	1.775	8.46-15.06	7.96-14.25	7.96-15.06
Area of LTC	9.80	1.699	9.18	2.050	9.50	1.879	6.97-13.23	6.39-13.36	6.39-13.36

Note:- AP: Anteroposterior Diameter, TD:-Transverse Diameter, MTC:- Medial tibial condyle, LTC:- Lateral tibial condyle, TTC:- Total tibial condyle, ICR:- Inter condylar region

Table 2: Statistical Analysis

Parameters	T value	P value	Infezence
AP MTC-t	0.399	0.65	Non Significant
TD MTC	0.852	0.80	Not Significant
AP LTC	1.538	0.93	Not Significant
TD LTC	1.229	0.888	Not Significant
TD TTC	0.685	0.752	Not Significant
AP TCR	0.523	0.699	Not Significant
C Upper end	2.516	0.007	Not Significant
L between U end & TT	0.255	0.600	Not Significant
Area TTC	0.714	0.761	Not Significant
Area MTC	0.942	0.825	Not Significant
Area LTC	1.265	0.892	Not Significant

Note:- AP: Anteroposterior Diameter, TD:-Transverse Diameter, MTC:- Medial tibial condyle, LTC:- Lateral tibial condyle, TTC:- Total tibial condyle, ICR:- Inter condylar region

right and left tibia is 4.19±0.374 and 4.14±0.365 respectively whereas Transverse diameter of total tibial condyle is 6.33±0.435 & 6.25 ±0.465 respectively.

Circumference of upper end of tibia in right and left side is 18.68± 1.490 and 19.60 ± 1.342. Length between upper end of tibia and tibial tuberosity is 2.68 ± 0.376 and 2.65 ± 0.513. Above finding shows that all measurements of right side tibia is either equal or little bit more than left side except Circumference of upper end where left side value is more than right.

Discussion

The geometry and anatomy of the knee is variable, irrespective of gender and human race and it should be considered carefully during designing process of the tibia prosthesis for the TKA.

Yan et al found the AP and transverse diameter on the proximal tibia section as 4.9± 0.39 cm and 7.3±0.56 cm respectively. In our study we got almost similar values of AP diameter as 4.16±0.368 but transverse diameter is 6.29±0.447 cm which is low than Yan et al study [9].

Ivan et al [4] found the mean transverse length on the right, left, and total tibia as 6.66 ±0.56, 6.62±0.51 and 6.64 ± 0.53 Cm. Our values of our study are almost similar to their study and our values are, 6.33±0.435, 6.25-±0.465 and 6.29±.0.447 [4]. Ivon found mean antero posterior length of medial condyle on the right, left, & total tibia as 4.08±0.42, 4.13±0.42, and 4.10± 0.42 cm and values are almost similar in our study as 4.10±0.375, 4.06+0.398 and 4.08±0.383. The mean AP length of lateral condyle on right, left & total tibia in her study was 3.54±0.39, 3.67±0.41 and 3.61± 0.40Cm. In our study the values are almost similar i.e. 3.43±0.355 3.27±0.439 and 3.35±±0.401.

The mean intercondylar AP length on right, left, & total tibia was 4.25±0.42, 4.49±0.44, and 4.20± 0.43 cm in her study & we got the values as 4.19±0.374, 4.14±0.365, 4.16±0.368 which is near bout same as above study. She also found the mean circumference of the upper end of tibia on the right, left & total tibia as 13.36±1.5, 19.33±1.44 and 19.35cm which is almost similar to our study i.e 18.68±1.490, 19.60±1.342±& 19.11±1.485cm respectively.The mean length from upper end of tibia to the tibial tuberosity in her study on the right, left and total tibia was 4.47±0.61, 4.60± 0.68, and 4.54cm while in our study the values are 2.68±0.376, 2.65 ±0.513 and 2.70±0.441 cm which is far less than Ivon study. The groove for ligamentum patellae was present in 73.91 of total number of bones in Ivon study while in our study we got that in 100%. Of bones. She found no statistical significance in any parameters of tibia on right and left side which coincides our study.

Chadani gupta et al [10] in 2015 found the mean transverse length on the right, left, and total tibia as 6.77± 0.31, 6.88± 0.65, and 6.83± 0.51 cm where as our values are little bit less than chandani gupta study i.e., 6.33±0.435, 6.25±0.465 & 6.29 ±0.447-cm . She found the mean Ap length of medial condyle on the right, left, and total tibia as 4.55±0.29, 4.36±0.47and 4.45± 0.40 cm. Whereas our values are almost similar to study as 4.10 +0.375, 4.06+0.398, and 4.08+-0.383.

The mean Antero prsterior length of lateral condyle on the right, left & total tibia in her study was, 4.08±0.27, 4.06±0.40and 4.07±0.34cm where as our values are somewhat less than her study i.e. 3.43± 0.355, 3.27±0.439, & 3.35± 0.401 cm.. The mean intercondylar Ap length on the right left and total tibia in her study was 4.66 ±0.32, 4.49 ±0.44 and4.57± 0.39 cm. Whereas values of our study are almost similar. i.e. 4.19±0.374, 4.14±0.365 and 4.16±0.368 which is almost similar to her study.

She also found the mean circumference of upper end of tibia on right, left, & total tibia as 18.95±0.68, 19.07±1.65, and 19.02±1.27cm, where as our study shows similar values as 18.68±1.490, 19.60±1.342 and 19.11±1.485. The mean length of upper end of tibia to tibia tuberosity in her study on right, left & total tibia was 5.06± 0.59,5.24±0.71, and 5.15± 0.65cm while our study indicates less value i.e 2.68±0.376, 2.65±0.513 and 2.66±0.441 cm. She found the groove for ligamentum patellae was present in 100% of bones which is similar to our study i.e. in 100% of bones.

Shivastava et al [11] found the mean transverse, Ap diameter of medial and lateral condyle on right side as 2.97, 3.86 cm and 2.92, 3.64 cm . They found the mean transverse, Ap diameter of medial and lateral condyle on left side as 2.75, 3.99cm and 2.97, 3.69 cm. while in our study we got the valves as 2.69, 4.10 cm and 2.86, 3.43 cm on the right side and 2.63, 4.06, and 2.75, 3.27 cm on the left side. They found total tibial condyle, medial condyle, lateral condoyle area on right & left side as 29.88, 11.52, 10.75 and 29.51 , 11.01, 10.52 cm^2 .These valves are somewhat more than our values i.e. 26.60, 11.06, 9.80 and 25.94, 10.63, 9.18 cm^2 .

Srivastava et al found that area covered by medial condyle is 38.56%. and by lateral tibial condyle is 35.97% out of total condyle area on right side. The area covered by medial tibial condyle is 37.32% and by lateral tibial condyle is 35.65% out of total tibial condyle area on left side which was little higher to

our study as the values in our study are 41.58% and 36.84% for medial and lateral condyle in right side and 40.97%, 35.38% on left side.

Knee osteoarthritis is one of the most common causes of disability in adults. The damage results from a complex interplay of joint integrity, biochemical processes, genetic and mechanical forces. Total and unicompartmental joint replacement have become the gold standard for treatment of osteoarthritis and other degenerative disorders of knee [12].

Total knee arthroplasty and UKA are both meticulous surgeries which necessitate the precision in the prosthesis sizing to ensure an effective result as well as long term survival of the same. The current challenges in knee prosthetic design are centered on attempting to produce normal kinematics, reducing wear & tear and hence achieving greater longevity. Hence suitable prosthetic design is crucial to restore the normal function in patients postoperatively [13]. Inadequate tibial coverage can lead to tibial implant collapse because of the load being [14].

Conclusion

Conventional prostheses available in the market are designed for Caucasians; Indians having smaller anatomical profiles would need smaller sized components of knee prosthesis. Hence the result of this study would be significant value in the manufacture of tibial component of knee prosthesis in the Indian population for both UKA as well as TKA. This study also confirms sizing of tibial component of south Indian population by comparing from other parts of country.

References

1. Standring S. Gray"s Anatomy; the Anatomical Basis of Clinical Practice. 39 th ed. London: Elsevier Churchill Livingston: 2005.p.1474-92.
2. Ljuneeren AE. The TuberositasTibiae and Extention in the knee joint. Acta Morphol Neeri Scand. 1976; 14:215-39.
3. Mark DG. Consistancy and accuracy of measurement of lower limb amputeeanthropometrics. JRRD. 2005; 42:131-40.
4. Ivan AS. Morphometric Study of Proximal End of Tibia; 2014.P.75. Available from;http://www.rguhs.ac.in/cdc/onlinecdc/uploads/01-M010-25888.doc.
5. Vaidya SV, Ranawat CS, Aroojis A, Laud NS. Anthropometric measurements to design total knee prosthesis for the Indian population. The Journal of Arthroplasty. 2000; 15(1):79-85.
6. Insall jn, Clarke HD. Historic development, classification and charecteristics of knee prosthesis. Fitz W, Scott RD and Insall JN. Unicompartmental total knee arthroplasty.in; Scott WN, editor. Insall and Scott surgery of knee . 4th edition, Vol,2. Philadelphia; Elsevier Churchill Livingston; 2006. p.1367-419.
7. Crockarell JR, Guyton JL. Arthroplastyof the knee.in: Canale ST, Beaty JH, editors. Campell"s Operative Orthopedics. 11th ed, Vol 1. Philadelphia: Mosby Elsevier; 2008.p.256-77.
8. Surendran S, Kwak DS, Lee UY, Park S E, Gopinathan P, Han SH et al.Anthropometry of the medial tibial condyle to design the tibial component forunicondylar knee arthroplasty for the Korean population. Knee Surg Sports Traumatol Arthrosc. 2007; 15:436-442
9. Yan JH, Yu B, Luo JW, Zuo LJ, Hua LQ, Zuo XH. 3d digitilization of the proximal tibia and its significance on designing the tibial component of total knee arthroplasty. Chin J Clin Anat. 2010; 28:138.
10. Chandani Gupta,Jitendra KumarSneha Guruprasad Kalthur. A Morphometric study of the proximal end of tibia in south Indian population with its clinical implications. Soudi Journal of Sports Medicine 2015; 15(1):166-169.
11. Srivastava A, Yadav A , Thomus RJ, Gupta N. Morphometric study of Tibial condylar area in the North Indian population.J Med Sci Clin Res 2015; 2:515-9.
12. Zanasi S. Innovation in total knee replacement : new trends in operative treatment and changes in perioperative management. Eur Orthop Traumatol. 2011; 2:21-31
13. Chaichankul C, Tanavalee A, Itiravivong P. Antropometric measurements of knee joints in Thai population: Correlation to the sizing of current knee prostheses. Knee 2011; 18:5-10.
14. Servien E, Saffarini M, Lustig S, Chomel S, Neyret Ph. Lateral versus medial tibial plateau: morphometric analysis and adaptabilityo with current tibial component design. Knee surgery sports Traumatol Arthrosc. 2008; 16:1141-1145.

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Ultrastructural Characteristics of Peripheral Nerves in Diabetic Peripheral Neuropathy: Is There a Structure-Function Inter-Relationship

Senthil P. Kumar

Abstract

This letter to editor is aimed at re-exploring the structure-function inter-relationship from an evidence-informed bench-to-bedside perspective for ultrastructural characteristics of peripheral nerves in diabetic peripheral neuropathy (DPN) and its implications for assessment and management of patients. Ultrastructural changes occurred in all parts of the peripheral nerves- axons, cell bodies, dendrites, myelin sheath and endplates.The ultrastructural changes were reported in both sympathetic and parasympathetic fibers, and occurred in both myelinated and unmyelinated nerve fibers. The ultrastructural changes responded to treatment by ponalrestat, an aldose reductase inhibitor. These findings from experimental studies on diabetic rats indicate that the peripheral nerve lesions in human diabetics were mainly due to metabolic impairment of nerve fibers, accompanying dysmetabolism of Schwann cells and diabetic microangiopathy.

Keywords: Ultrastructure; Morphometry; Histochemical Study; Neuroanatomy; Diabetic Neuropathy.

Dear Sir,

This letter to editor is aimed at re-exploring the structure-function inter-relationship from an evidence-informed bench-to-bedside perspective for ultrastructural characteristics of peripheral nerves in diabetic peripheral neuropathy (DPN) and its implications for assessment and management of patients.

Ultrastructural changes occurred in all parts of the peripheral nerves- axons, cell bodies, dendrites, myelin sheath and endplates. Carson et al [1] found axonal degeneration, disruption of myelin, accumulation of electro-dense material in axons, satellite cells and Schwann cells, increased frequency of pi granules of Reich in Schwann cells, enlarged mitochondria, and proliferated and thickened Schwann cell basal laminae in peripheral nerves of rats which correlated with degenerative and regenerative changes secondary to alterations in lipid metabolism.

The ultrastructural alterations in Schwann cells were reported by Sima [2] who found conspisuousearly changes of mitochondrial accumulation of glycogen in the axons and the development of honey-combed Schwann cell-axon networks in peripheral nerves of diabetic insulin-dependent BB-Wistar-rats which later showed axonal dwindling and disintegration in both myelinated and unmyelinated fibers; and by Sima and Robertson [3] who found development of honeycombed Schwann cell-axon networks followed by axonal atrophy in both myelinated and unmyelinated fibers of axons, later accompanied by secondary corrugated myelin breakdown in mutant diabetic mice.

The ultrastructural changes were found in both sympathetic and parasympathetic fibers as shown by Yagihashi and Sima [4] who studied parasympathetic fibers using electron-microscopic and morphometric studies and found increased numbers of axonal glycogenosomes and axonal sequestration in unmyelinated fibers of the diabetic vagus nerve and myelinated fibers of the penile nerve, with diminished fiber size; and by Yagihashi and

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Sima [5] who studied sympathetic nerves (paravertebral thoracic ganglion cells, preganglionic myelinated fibers of the white ramus, and postganglionic unmyelinated fibers of the gray ramus communicans) using ultrastructural and morphometric techniques and found pre-ganglionic axonal dystrophy, the ganglionic cells had decreased number of synapses, and the postganglionic fibers in the gray ramus had an increased number of glycogenosomes, axonal sequestration, and reduction in axonal size, accompanied bydegenerative changes of myelin sheaths, various kinds of cytoplasmic inclusion bodies (crystalloid, lamellar inclusion bodies and lipids-like droplets), aggregates of glycogen particles in the Schwann cell cytoplasm and basement membrane hyperplasia of Schwann cells.

In addition, Schmidt et al [6] studied prevertebral and paravertebral sympathetic and vagal parasympathetic structures in hamsters and found large numbers of markedly dilated axons, suggestive of neuroaxonal dystrophy. Dystrophic axons were also found to contain substance P- and gastrin-releasing peptide (gastrin-releasing peptide/ bombesin)-like staining but were not found to be labeled by antisera directed against vasoactive intestinal peptide, dynorphin-B, somatostatin, leu- and met-enkephalin and neuropeptide tyrosine; and Schmidt and Plurad [7] examined Ileal mesenteric nerves of streptozotocin(STZ) diabetic rats and found neuroaxonal dystrophy with dystrophic axons present in superior mesenteric gangliawhich also had increased number of postsynaptic dendritic processes dilated by unusual tubular profiles.

The ultrastructural changes occurred in both myelinated and unmyelinated nerve fibersas shown by Yagihashiand Matsunaga [8] who found axonal degeneration in sural nerves of diabetic rats, with following structural changes of the axons: axonal dwindling, depletion of axoplasmic organelles, vacuolarization and an increase in neurofilaments.

Treatment-induced ultrastructural effects were reported by Yagihashiet al [9] who found beneficial effects of ponalrestat, an aldose reductase inhibitor in STZ-induced diabetic rats, by reduced sorbitol and fructose levels, normalizing myo-Inositol levels andmyelinated nerve fiber size and fiber occupancy of sural nerves.

The findingsfrom experimental studies on diabetic rats indicate that the peripheral nerve lesions in human diabetics were mainly due to metabolic impairment of nerve fibers, accompanying dysmetabolism of Schwann cells and diabetic microangiopathy. Can future randomized clinical trials examine the therapeutic effects in terms of changes in ultrastructural characteristics so that a bench-to-bedside translation of evidence into practice could be implemented in diabetes care?

References

1. Carson KA, Bossen EH, Hanker JS.Peripheral neuropathy in mouse hereditary diabetes mellitus. II. Ultrastructural correlates of degenerative and regenerative changes.NeuropatholApplNeurobiol. 1980; 6(5):361-74.
2. Sima AA.Peripheral neuropathy in the spontaneously diabetic BB-Wistar-rat.An ultrastructural study.ActaNeuropathol. 1980; 51(3): 223-7.
3. Sima AA, Robertson DM.Peripheral neuropathy in the diabetic mutant mouse. An ultrastructural study.Lab Invest. 1979; 40(6):627-32.
4. Yagihashi S, Sima AA.Diabetic autonomic neuropathy in BB rat.Ultrastructural and morphometric changes in parasympathetic nerves. Diabetes. 1986; 35(7):733-43.
5. Yagihashi S, Sima AA.Diabetic autonomic neuropathy in the BB rat.Ultrastructural and morphometric changes in sympathetic nerves. Diabetes. 1985; 34(6):558-64.
6. Schmidt RE, Plurad DA, Plurad SB, Cogswell BE, Diani AR, Roth KA.Ultrastructural and immunohistochemical characterization of autonomic neuropathy in genetically diabetic Chinese hamsters. Lab Invest. 1989; 61(1):77-92.
7. Schmidt RE, Plurad SB.Ultrastructural and biochemical characterization of autonomic neuropathy in rats with chronic streptozotocin diabetes.J NeuropatholExp Neurol. 1986; 45(5):525-44.
8. Yagihashi S, Matsunaga M.Ultrastructural pathology of peripheral nerves in patients with diabetic neuropathy. Tohoku J Exp Med. 1979; 129(4):357-66.
9. Agihashi S, Kamijo M, Ido Y, Mirrlees DJ.Effects of long-term aldose reductase inhibition on development of experimental diabetic neuropathy. Ultrastructural and morphometric studies of sural nerve in streptozocin-induced diabetic rats. Diabetes. 1990; 39(6):690-6.

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The second page should carry the full title of the manuscript and an abstract (of no more than 150 words for case reports, brief reports and 250 words for original articles). The abstract should be structured and state the Context (Background), Aims, Settings and Design, Methods and Materials, Statistical analysis used, Results and Conclusions. Below the abstract should provide 3 to 10 keywords.

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State the background of the study and purpose of the study and summarize the rationale for the study or observation.

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Include summary of key findings (primary outcome measures, secondary outcome measures, results as they relate to a prior hypothesis); Strengths and limitations of the study (study question, study design, data collection, analysis and interpretation); Interpretation and implications in the context of the totality of evidence (is there a systematic review to refer to, if not, could one be reasonably done here and now?, What this study adds to the available evidence, effects on patient care and health policy, possible mechanisms)? Controversies raised by this study; and Future research directions (for this particular research collaboration, underlying mechanisms, clinical research). Do not repeat in detail data or other material given in the Introduction or the Results section.

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Standard journal article

[1] Flink H, Tegelberg Å, Thörn M, Lagerlöf F. Effect of oral iron supplementation on unstimulated salivary flow rate: A randomized, double-blind, placebo-controlled trial. J Oral Pathol Med 2006; 35: 540-7.

[2] Twetman S, Axelsson S, Dahlgren H, Holm AK, Källestål C, Lagerlöf F, et al. Caries-preventive effect of fluoride toothpaste: A systematic review. Acta Odontol Scand 2003; 61: 347-55.

Article in supplement or special issue

[3] Fleischer W, Reimer K. Povidone iodine antisepsis. State of the art. Dermatology 1997; 195 Suppl 2: 3-9.

Corporate (collective) author

[4] American Academy of Periodontology. Sonic and ultrasonic scalers in periodontics. J Periodontol 2000; 71: 1792-801.

Unpublished article

[5] Garoushi S, Lassila LV, Tezvergil A, Vallittu PK. Static and fatigue compression test for particulate filler composite resin with fiber-reinforced composite substructure. Dent Mater 2006.

Personal author(s)

[6] Hosmer D, Lemeshow S. Applied logistic regression, 2nd edn. New York: Wiley-Interscience; 2000.

Chapter in book

[7] Nauntofte B, Tenovuo J, Lagerlöf F. Secretion and composition of saliva. In: Fejerskov O, Kidd EAM,

editors. Dental caries: The disease and its clinical management. Oxford: Blackwell Munksgaard; 2003. p. 7-27.

No author given

[8] World Health Organization. Oral health surveys - basic methods, 4th edn. Geneva: World Health Organization; 1997.

Reference from electronic media

[9] National Statistics Online—Trends in suicide by method in England and Wales, 1979-2001. www.statistics.gov.uk/downloads/theme_health/HSQ 20.pdf (accessed Jan 24, 2005): 7-18. Only verified references against the original documents should be cited. Authors are responsible for the accuracy and completeness of their references and for correct text citation. The number of reference should be kept limited to 20 in case of major communications and 10 for short communications.

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