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Correlation of Endoscopic and Histopathological Diagnosis of Upper Gastrointestinal Lesions: A Study in a Tertiary Care Centre in Coastal Karnataka

Kirana Pailoor*, Ramesh Naik C.N., Murali Keshava S.***, Hilda Fernandes****, Jayaprakash C.S.*****, Nisha J. Marla********

Abstract

Background and objective: Endoscopy and histopathological examination plays an important role in the treatment of gastrointestinal lesions. The present study was done to evaluate and correlate the endoscopic and histopathological diagnosis of the neoplastic and non-neoplastic upper gastrointestinal lesions.

Materials and methods: One hundred endoscopic biopsies were studied both retrospectively and prospectively. Biopsies were retrieved using flexible fibre-optic endoscope and also video endoscope. They were transferred to a bottle containing 10% neutral formalin, processed and stained routinely with haematoxylin and eosin. Special stains such as Mucicarmine and Giemsa were done as and when required.

Results: Out of 100 endoscopic biopsies, 34% were from esophagus, 48% from gastric, 15% from gastro-esophageal junction and 3% from duodenum. The correlation of endoscopic and histopathological diagnosis of upper gastrointestinal lesions was 73.12%. The sensitivity of these upper gastrointestinal lesions was 76.67%, specificity 94.28%, positive predictive value 85.19% and negative predictive value was 90.41%.

Conclusion: Endoscopic examination and biopsy is a convenient procedure for accurate objective assessment of patients with upper gastrointestinal symptoms. Endoscopy is incomplete without biopsy and histopathology is the gold standard for the diagnosis of endoscopically detected lesions.

Keywords: Endoscopic biopsy; Histopathology; Upper gastrointestinal lesions; Esophageal biopsy; Gastric biopsy; Duodenal biopsy.

Introduction

Human gastrointestinal tract is long and tortuous. To facilitate diagnosis of upper gastrointestinal lesions, endoscopy and histology are complementary. Over the years, it has been realized that the endoscopic appearances are highly suggestive but are not pathognomic and they need histological confirmation. In endoscopic biopsy reporting of gastrointestinal tract, the diagnosis of malignancy is easy and well accepted by the clinicians especially when the growth is obvious on endoscopy. Then the job of the pathologist becomes easy enough to give other details related to malignancy. But the real skillful task is in cases of non-neoplastic lesions. Here is the role of specialty reporting pathologist having experience and knowledge about the clinical and endoscopic spectrum of the disease. Many a times, severity of the lesion is more on endoscopy but the biopsy from that site shows only mild inflammation e.g., gastritis or duodenitis.[1-4]

Gastroenterologists rely on the results of the biopsy for correct diagnosis. Therefore, histopathology is an essential complement to endoscopic examination.[5] It has been aptly described that we may now be merely scratching the surface of what lies ahead in

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Table 1: Age and sex wise distribution of upper gastrointestinal endoscopic biopsy cases

Age in Years	Sex		Total No. of Cases	Percentage
	Male	Female		
21-30	02	01	3	3%
31-40	10	04	14	14%
41-50	11	3	14	14%
51-60	16	08	24	24%
61-70	18	9	27	27%
71-80	13	02	15	15%
81-90	03	00	03	03%
Total	73	27	100	100%

the marriage of microscopy and endoscopy.[6] There are only few studies on endoscopy-histology correlation. This study highlights the correlation of endoscopic and histopathological diagnosis of neoplastic and non-neoplastic upper gastrointestinal lesions.

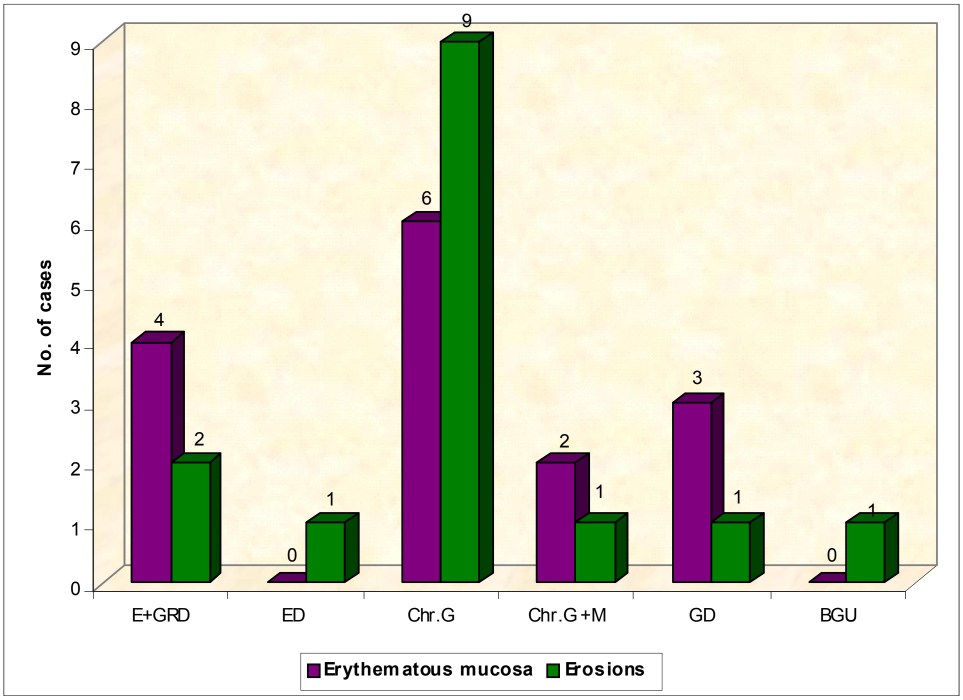
Materials and methods

A total number of 100 upper gastrointestinal biopsy specimens from oesophagus, stomach and first part of duodenum were studied retrospectively over a period of two years. Patients who were clinically diagnosed with upper gastro-intestinal lesions were taken up for endoscopy. Details of the patient were recorded such as the age, sex, symptoms, clinical diagnosis, investigations, and endoscopic findings with diagnosis. The lesions were diagnosed on gross visualization during endoscopy. Patients of both gender, all ages, inpatients and outpatients and those with diagnostic upper gastrointestinal lesions were included in the study. The cases in which biopsies could not

Table 2: Incidence of different upper gastrointestinal lesions

Lesions	No. of Cases	Percentage
Esophagus		
1. Chronic Nonspecific Esophagitis	04	4%
2. Gastro Esophageal Reflux Disease	02	2%
3. Barrett's Esophagitis	04	4%
4. Dysplasia	01	1%
5. Squamous Cell Carcinoma	26	26%
6. Adenocarcinoma	01	1%
Stomach		
1. Chronic gastritis	15	15%
2. Chronic gastritis + metaplasia	03	3%
3. Benign Gastric Ulcer	01	3%
4. Dysplasia	04	4%
5. Adenocarcinoma	29	29%
6. Squamous cell carcinoma	0	0
Duodenum		
1. Duodenitis	03	3%
2. Non specific duodenal ulcer	01	1%
3. Tumors	0	0%
GE Junction		
1. Squamous cell carcinoma	0	0
2. Adenocarcinoma	06	6%
Total	**100**	**100%**

Figure 1: Endoscopic appearance and histopathological diagnosis of non-neoplastic upper GI lesions.



E+GRD: Esophagitis & Gastroesophageal Reflux Disease, ED: Esophageal Dysplasia, Chr.G: Chronic Gastritis, Chr.G+M: Chronic Gastritis & Metaplasia, GD: Gastric Dysplasia, BGU: Benign Gastric Ulcer

Figure 2: Chronic gastritis with intestinal metaplasia, Haematoxylin & Eosin x 100

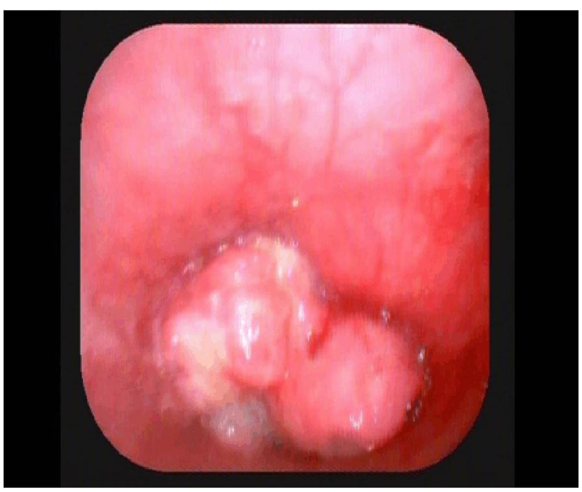
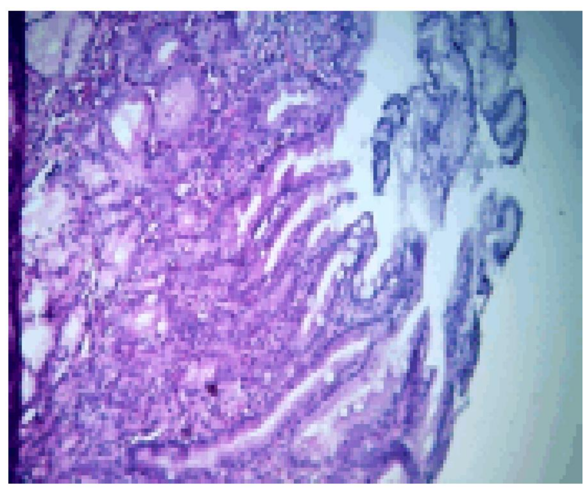


Figure 3: Helicobacter pylori, Giemsa x1000



be done and endoscopy done for therapeutic purposes were excluded from the study. Flexible fibre-optic endoscope, Pentax LH-150 PC and video-endoscope, Pentax EHK 1000 were used in this study.

The biopsy tissue obtained by using biopsy forceps was transferred to a bottle containing 10% neutral formalin. The tissue was processed and the sections were stained with Hematoxylin and Eosin. Special stains such as Mucicarminbe and Giemsa were done as and when required. A histopathological diagnosis was made. Later a correlation of endoscopic and histopathological diagnosis was carried out. Data was collected by purposive sampling method and analyzed for frequency, percentage, specificity and sensitivity. Kappa statistics was used to find

Figure 4: Endoscopic appearance of proliferative growth in mid-esophagus

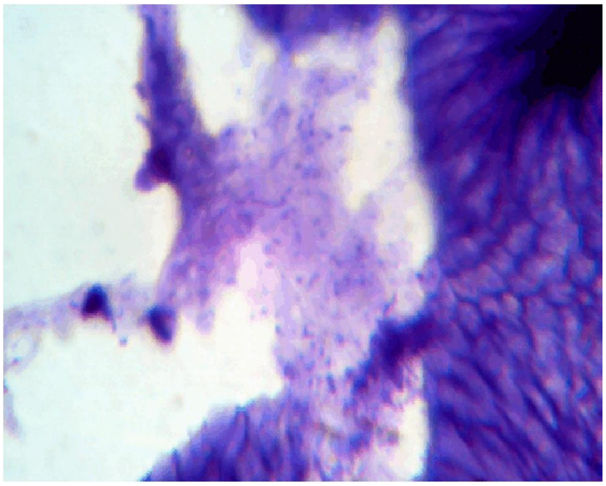
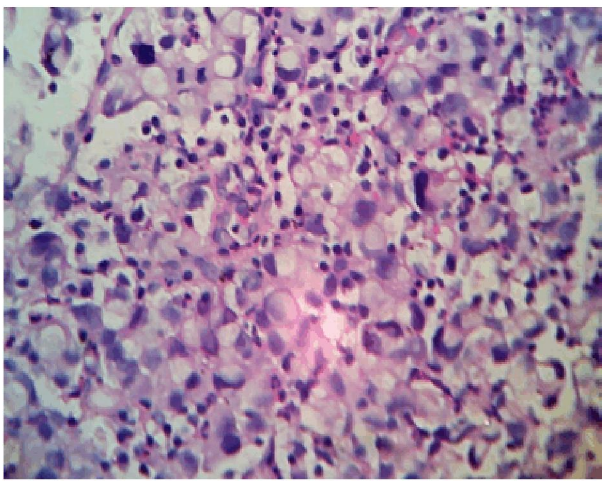


Figure 5: Signet ring cell carcinoma of stomach, Haematoxylin & Eosin x 400



an agreement with the diagnostic tests.

Results

Totally 100 upper gastrointestinal tract biopsies were examined. Of these biopsies, 34% were from esophagus, 48% from gastric, 15% from gastro-esophageal junction and 3% from duodenum.

There were 73 male and 27 female patients with male to female ratio 3:1. The highest incidence was seen between 61-70 years (27%) and the lowest incidence was seen in 21-30 yeas (3%) and 81-90 years (3%) [Table 1]. The most commonly encountered lesion was gastric carcinoma (29%) and esophageal carcinoma (27%) [Table 2].

The ratio of neoplastic to non-neoplastic conditions amongst the esophageal lesions was 2.5:1. Four cases (36.36%) were diagnosed histologically as Barrett's which on endoscopy was diagnosed as gastroesophageal reflux disease. The peak incidence of gastritis was seen in the sixth decade. Male preponderance was seen in all the non-neoplastic upper gastrointestinal lesions (3:1 for gastritis, esophagitis and Barrett's and 3:0 for duodenitis). Amongst the non-neoplastic upper gastrointestinal lesions, the highest number of cases belonged to gastritis histologically, 9 of which presented endoscopically as erosions and 6 as an erythematous mucosa [Figure 1]. Histologically, one case of chronic gastritis showed intestinal metaplasia [Figure 2] and another showed the presence of Helicobacter pylori [Figure 3].

The maximum number of malignant cases was from stomach (46.77%) and esophagus (43.55%). The peak incidence of both the malignancies was in the seventh decade (41.38% and 29.63% in gastric and esophageal carcinomas respectively). The youngest age at presentation was 27 years and oldest age was 84 years with a mean age of 55.5 years. The

Table 3: Comparative incidence of upper gastrointestinal malignancies by endoscopy

Authors	Site			
	Esophagus	Stomach	Duodenum	Others
Lal *et al*[10]	84%	12%	4%	-
Paymaster JC *et al*[13]	66.5%	16.1%	-	17.4%
Devi KR *et al*[14]	54.3%	22.5%	-	23.2%
Prabhakar *et al*[15]	44.9%	6.17%	-	48.93%
Sauerbruch *et al*[16]	46.4%	50.7%	2.9%	-
Present study	43.55%	46.77%	-	9.68%

Table 4: Statistical analysis of upper gastrointestinal lesions

Kappa Statistics (Correlation)	73.12%
Sensitivity	76.67%
Specificity	94.28%
Positive Predictive Value	85.19%
Negative Predictive Value	90.41%

male to female ratio of esophageal carcinoma was 1.5:1 and that of gastric carcinoma was 2:1. Squamous cell carcinoma of esophagus on endoscopy presented commonly as proliferative growth (53.85%) [Figure 4]. Only one case of adenocarcinoma esophagus was seen which presented as an ulcero-proliferative growth. Esophageal carcinoma was commonly seen in the middle one-third (51.85%) followed by lower one-third (44.45%) and upper one-third (3.7%) of the esophagus.

On endoscopy, majority (55.17%) of adenocarcinoma of stomach presented as an ulcerative growth and only one case as an erythematous mucosa. Twenty nine cases were from stomach and six cases from gastro-esophageal junction. Most of the cases of adenocarcinoma stomach were of tubular type (80%). All six cases (17.14%) from gastro-esophageal junction were of signet ring cell type [Figure 5] and only one case of gastric adenocarcinoma was of mucinous type.

Eight cases (57.12%) were diagnosed as benign gastric ulcer on endoscopy was found to be adenocarcinoma histologically. Two cases (9.7%) were noticed as gastric carcinoma on endoscopy was diagnosed to be chronic gastritis histologically.

Discussion

The present study consisted of one hundred esophagogastro duodenal biopsies, out of which 34%, 48%, 15% and 3% were from esophagus, stomach, GE junction and duodenum respectively. This was almost similar to a study done by Kazi *et al*[7] except for the number of duodenal biopsies which were 60.3% in his study.

In the present study, the peak incidence of the esophagogastroduodenal lesions was in the seventh decade. The mean age was of 55.5 years which almost simulates a study conducted by Behar *et al*[8] and Bogomeltz *et al*[9] The youngest patient was 27 years old and the oldest patient was 84 years old. It was almost similar to a study by Bogomeltz *et al*[9] and Lal *et al*[10]. Male to female ratio of esophagogastroduodenal lesions in our study was 3:1. Kumar *et al*[11], Misra *et al*[12]. and Paymaster *et al*[13] had a similar observation in their studies. Whereas, contrast findings were observed by Devi *et al*.[14]

The percentage of esophageal carcinoma in the present study was 43.55% which was lower than that of other studies [Table 3].[10,13-16] The percentage of gastric malignancy was 46.77% which was higher than other studies[10,13-15] except that of Sauerbruch *et al*[16] [Table 3]. In our study, gastroesophageal junctional malignancies constituted 9.68%.

The sensitivity and specificity, positive predictive value and negative predictive value of upper gastrointestinal lesions were 76.67%, 94.28%, 85.19% and 90.41% respectively in the present study [Table 4]. The correlation of endoscopic and histopathological diagnosis of upper gastrointestinal lesions in the present study was 73.12% which was in contrast to a study by Misra *et al*.[12] According to a study done by Gad[17], only 42% correlation was noticed.

Out of six cases diagnosed as esophagitis on endoscopy, four cases were confirmed histopathologically. Four cases presented as erythematous mucosa and two cases of Gastroesophageal reflux disease as erosions on endoscopy. The sensitivity, specificity, positive predictive value and negative predictive value for esophageal lesions in the present study were 96.88%, 95.59%, 91.18% and 98.48% respectively. The correlation of endoscopic and histopathological diagnosis of esophageal lesions was 90.98%. This is similar to the observation done by Behar *et al*[8] but in contrast to the findings of Gruber *et al*[18] who in conventional esophagoscopy found a sensitivity of 40.6%, specificity of 78.9%, positive predictive value of 52% and negative predictive value of 70.3%.

Out of the 14 cases diagnosed as benign gastric ulcer on endoscopy, eight were found to be malignant and two were chronic gastritis on histopathology. In the present study, the correlation of endoscopic and histopathological diagnosis gastric lesions was 57.28%. The sensitivity, specificity, positive predictive value and negative predictive value were 65.96%, 90.57%, 86.11% and 75% respectively. Kazi *et al*[7] also found correlation between endoscopic and histopathological diagnosis in 240 patients undergoing upper gastrointestinal endoscopy for dyspeptic symptoms. One out of six benign looking ulcers in esophagus and 1 out of 9 benign looking gastric ulcers on endoscopy turned out to be malignant on subsequent histology.

The analysis of all the cases which did not show endoscopy – histology correlation was done. They were found to be due to stricturous or necrotic growth, superficial biopsy and absence of goblet cells in Barrett's esophagus. Careful evaluation of the clinical data, expertisation on the part of endoscopist in choosing the appropriate site are therefore needed, apart from the proper processing of biopsy tissue and meticulous reporting by the histopathologist for interpretation of endoscopic biopsies.[19,20]

Conclusion

Endoscopic examination and biopsy is a convenient procedure for accurate objective assessment of patients with upper gastrointestinal symptoms. It is recommended as the first investigation in the work up of a patient with dyspeptic symptoms. Neoplastic lesions were found to be more common than the non-neoplastic lesions in both, esophagus and stomach. The correlation of endoscopic and histopathological diagnosis of upper gastrointestinal lesions was 73.12%. Endoscopy is incomplete without biopsy and histopathology is the gold standard for the diagnosis of endoscopically detected lesions. Endoscopic biopsy correlation reflects important advances in understanding the biology and pathophysiology of the disease. It provides new diagnostic information, knowledge about the recent advances and thereby assists in improving patient management.

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References

1. Hopkins HH. Optical principles of endoscope. In: Berci G Ed. Endoscopy. 2nd ed. New York: Appleton Century Grafts; 1976, 3-26.
2. Tytgat GNJ. Role of endoscopy and biopsy in the work up of dyspepsia. *Gut.* 2002; 50(suppl IV): 13-16.
3. Kang JY, LaBrooy SJ, Wee A. Gastritis and duodenitis – a clinical, endoscopic and histological study and review of the literature. *Ann Acad Med Singapore* 1983; 12: 539-544.
4. Levy N, Stermer E, Boss JM. Accuracy of endoscopy in the diagnosis of inflamed gastric and duodenal mucosa. *Isr J Med Sci.* 1985; 21: 564-8.
5. McBroom HM, Ramsay AD. The clinicopathological meeting : A means of auditing diagnostic performance. *Am J Surg Pathol.* 1993; 17: 75-80.
6. Nathanson MH. Confocal colonoscopy: More than skin deep. *Gastroenterol.* 2004; 127: 987-1000.
7. Kazi JI, Alam SM, Kazi AM, Anwar A, Shamsi Z. Correlation of endoscopic and histological diagnosis in upper gastrointestinal lesions. *J Pak Med Assoc.* 1990; 40(12): 281-3.
8. Behar J, Sheahan DC. Histologic abnormalities in Reflux Esophagitis. *Arch Pathol.* 1975; 99: 387-92.
9. Bogomoletz WV, Molas G, Gayet B, Potet F. Superficial squamous cell carcinoma of the

esophagus. *Am J Surg Pathol.* 1989; 13(7): 535-546.

10. Lal N, Bhasin DK, Malik AK, Gupta NM, Singh K, Mehta SK. Optimum number of biopsy specimens in the diagnosis of carcinoma of the oesophagus. *Gut* 1992; 33: 724-726.
11. Kumar A, Bansal R, Pathak VP, Kishore S, Arya PK. Histopathological changes in gastric mucosa colonized by H. pylori. *Indian J Pathol Microbiol.* 2006; 49(3): 352-356.
12. Misra V, Misra SP, Shukla SK, Jaiswal PK, Agarwal R, Tondon S. Endoscopic and histological changes in upper gastrointestinal tract of patients with chronic renal failure. *Indian J Pathol Microbiol.* 2004; 47(2).
13. Paymaster JC, Sanghvi LD, Gangadharan P. Cancer in the gastrointestinal tract in Western India. *Cancer.* 1968; 21(2): 279-288.
14. Devi KR, Suvarna N. Pattern of gastrointestinal tumors in North Kerala. *Indian J Cancer.* 1980; 17: 159-163.
15. Prabhakar BR, Maingi K, Sahni A. Incidence of gastrointestinal malignancies in Punjab. *Indian J Pathol Microbiol.* 1988; 31(4): 262-265.
16. Sauerbruch T, Schreiber MA, Schussler P, Permanetter W. Endoscopy in the diagnosis of gastritis. Diagnostic value of endoscopic criteria in relation to histological diagnosis. *Endoscopy.* 1984; 16(3): 101-4.
17. Gad A. Erosion: a correlative endoscopic histopathologic multicenter study. *Endoscopy.* 1986; 18(3): 76-9.
18. Gruber AC, de Barros SG, Piitten AC *et al*. Esophageal dysplasia and chronic esophagitis; detection at upper gastrointestinal endoscopy. *Arq Gastroenterol.* 1998; 35(4): 258-63.
19. Odze RD, Maley CC. Neoplasia without dysplasia, Lessons from Barrett's esophagus and other tubal gut neoplasms. *Arch Pathol Lab Med.* 2010; 134: 896-906.
20. Voltaggio L, Montgomery EA, Lam-Himlin D. A clinical and histopathologic focus on Barrett esophagus and Barrett-related dysplasia. *Arch Pathol Lab Med.* 2011; 135: 1249-1260.

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Original Article

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Study of Modes of Identification, Cause of Death and Time since Death in Cases of Decomposed Bodies: A Prospective Study

Bhuva Shailesh D.*, Vijapura Makbulali T., Mangal H. M.***, Kyada Hetalkumar C.****, Momin Sadikhusen G.*****, Doshi Sunil M.******

Abstract

The owing to the decomposition of dead bodies, the identification, cause of death and time since death of a dead body becomes very difficult or may even impossible.[1-3] So in order to outcome this problem, present study was conducted in the Department of Forensic Medicine at P.D.U. Medical College, RAJKOT (Gujarat) from 1st September 2009 to 15th May 2011 on dead bodies brought to the mortuary of this institution. During that period out of total 4034 dead bodies, 100 dead bodies showing the signs of decomposition were received for the present study which accounts 2.47% deaths. Identity was established in 71% cases while 29% cases remained unidentified. In majority of cases (68%) cause of death was unnatural while in 6% cases cause of death was natural. No cause of death could be detected in 26% cases. In 52% cases, *time since death* was1-3 days followed by 29% cases in which time since death was 3-7 days.

Keywords: Decomposition; Identification; Cause of death; Time since death.

Introduction

Owing to the rapid decomposition of dead bodies in warm climates as in India or because of damage by wild animals the identification of a dead body becomes very difficult or may even impossible. If the body is not identified, the investigations in all medico-legal cases come to a standstill from the beginning, as establishment of identity is the first step in investigations. Due to the same reason the chances of getting positive findings to derive cause of death are progressively reduced as the state of decomposition advances. As the decomposition progresses, the chances of getting reasonably accurate time since death are less. Determination of reasonably accurate time since death has a bearing on the issue of alibiandopportunity in criminal cases.In civil cases also, time since death may have implications. In all above circumstances autopsy surgeon has to play an important role by providing data related to identification, cause of death and time since death which provides important clues to the investigators to solve out the cases.[4-7]

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Material and Method

Present study was conducted in the Department of Forensic Medicine at P. D. U. Medical College, RAJKOT (Gujarat) from 1st September 2009 to 15th May 2011. During this period out of total 4034 dead bodies, 100 dead bodies showing the signs of decomposition were received. These dead bodies were selected for the study irrespective of identified or unknown, age group, gender, religion, marital status and place from where the body was received.

Table 1: Distribution Of Cases Into Decomposed Bodies And Skeletal Remains

	No. Of Cases (%)
Decomposed Bodies	93 (93%)
Skeletal Remains	7 (7%)
Total	100 (100%)

After receiving dead body in mortuary, a detailed history about person last seen alive, the place where body found, and the environment of that place were recorded in the specially designed Proforma. Thorough examination of dead bodies was done to study the changes of decomposition, data for identification, findings suggestive of cause of death and time since death. The data so collected are compiled on the specially designed proforma, tabulated in master-chart, and subjected to computer assisted analysis and conclusions were drawn.

Observations

Out of total 100 cases, 93% cases were in various stage of decomposition and 7% cases were reduced to skeleton

According to Table 2, it was found that 55% corpses were identified while 45% corpses were unidentified. Out of 93 cases of decomposed bodies, 50 (53.76%) cases were identified while among 7 cases of skeletonised remains, 5 (71.42%) cases were identified.

Table 3 shows that out of 45 unidentified cases, on follow up, the 35.55% cases were identified and 64.45% cases were remains unidentified.

Table 4 indicates that in 55 cases identity was established by investigating authority before autopsy. Identity was established in 16 cases after autopsy. Out of these 16 cases, clothes and ornaments formed the main basis for identification in 56.25% cases followed by DNA profile (37.50%) and personal belongings (6.25%).

Table 5 shows that in maximum number of cases (68%) cause of death was unnatural; out of them; cause of death was drowning in 40%

Table 2: Distribution Of Cases According To Whether Corpse Was Identified Or Not

	Identified	Unidentified	Total (%)
Decomposed Bodies	50 (50%)	43 (43%)	93 (93%)
Skeletal Remains	5 (5%)	2(2%)	7 (7%)
Total	55 (55%)	45 (45%)	100 (100%)

Table 3: Distribution Of Unidentified Cases According To Their Identification Status On Follow Up (45 Cases)

	Identified	Remain Unidentified	Total (%)
Decomposed Bodies	15(33.33%)	28(62.22%)	43(95.55%)
Skeletal Remains	1(2.22%)	1(2.22%)	2(4.44%)
Total	16(35.55%)	29(64.45%)	45(100%)

Table 4: Distribution Of Cases According To Various Modes By Which Identification Of Corpse Was Done (In 71 Cases)

No. Of Identified Dead Bodies	Data For Identification				
	Clothes & Ornaments	Personal Belongings	DNA Profile	Tattoo Mark	Total (%)
Identified Before Autopsy (55 Cases)	36 (65.45%)	16 (29.09%)	-	3 (5.46%)	55 (100%)
Identified After Autopsy (16 Cases)	9 (56.25%)	1 (6.25%)	6 (37.50%)	-	16 (100%)

Table 5: Distribution Of Cases According To Cause Of Death

<table>
<tr><th colspan="3">Cause Of Death</th><th>Decomposed Bodies</th><th>Skeletal Remains</th><th>Total (%)</th></tr>
<tr><td rowspan="8">Unnatural Death</td><td colspan="2">Drowning</td><td>38 (38%)</td><td>2 (2%)</td><td rowspan="8">68 (68%)</td></tr>
<tr><td rowspan="3">Mechanical Injuries</td><td>Head Injuries</td><td>8 (8%)</td><td>-</td></tr>
<tr><td>Firearm Injuries</td><td>5 (5%)</td><td>-</td></tr>
<tr><td>Others</td><td>2 (2%)</td><td>-</td></tr>
<tr><td colspan="2">Poisoning</td><td>10 (10%)</td><td>-</td></tr>
<tr><td colspan="2">Strangulation</td><td>1 (1%)</td><td>-</td></tr>
<tr><td colspan="2">Electrocution</td><td>1 (1%)</td><td>-</td></tr>
<tr><td colspan="2">Hanging</td><td>1 (1%)</td><td>-</td></tr>
<tr><td rowspan="2">Natural Death</td><td colspan="2">Coronary Insufficiency</td><td>5 (5%)</td><td>-</td><td rowspan="2">6 (6%)</td></tr>
<tr><td colspan="2">Lung Pathology</td><td>1(1%)</td><td>-</td></tr>
<tr><td>No Opinion</td><td colspan="2"></td><td>21 (21%)</td><td>5 (5%)</td><td>26 (26%)</td></tr>
<tr><td>Total</td><td colspan="2"></td><td>93 (93%)</td><td>7 (7%)</td><td>100(100%)</td></tr>
</table>

Table 6: Distribution Of Cases According To Time Since Death

Time Since Death	Decomposed Bodies	Skeletal Remains	Total (%)
1-3 Days	52 **(52%)**	-	52 **(52%)**
3-7 Days	29 **(29%)**	-	29 **(29%)**
1-3 Weeks	06 (6%)	1 (1%)	7 (7%)
3weeks-3months	06 (6%)	3 (3%)	9 (9%)
3-6 Months	-	3 (3%)	3 (3%)
Total	93 (93%)	7 (7%)	100 (100%)

cases followed by mechanical injuries (15%), poisoning (10%), hanging (1%) strangulation (1%) and electrocution (1%). 6% cases were of natural death which include coronary insufficiency (5%) and 1% case death was due to lung pathology. Here in 26% cases, cause of death could be detected.

Table 6 shows that 81% cases in which time since death was less than 7 days. Whereas 7% cases were in stages of advanced decomposition in which time since death was within 1 to 3 weeks. In majority of cases (6%) of skeletal remains, time since death was within 3 weeks to 6 months duration and in only one case, the body was reduced to skeleton in 5 to 15 days of death.

Discussion

Identification is of prime importance in decomposed bodies as features become bloated as decomposition progressed.[1,2,8] In present study it was found that 71% cases were identified while 29% cases were unidentified. Most of the corpses were identified by deceased's family member, relatives and friends.

Among 55 cases which were identified before autopsy, majority of cases (65.45%) were identified by clothes and ornaments followed by 29.09% personal belongings e.g. pocket contents, wrist watch, mobile phone etc. and 5.46% by tattoo marks.

Among 16 cases which were identified after autopsy, majority of cases (56.25%) were identified by clothes and ornaments followed by 37.50% DNA Fingerprinting and 6.25% by personal belongings e.g. pocket contents, wrist watch, mobile phone etc.

It is stated by Berry A J Fisher and others that fingerprinting is very useful technique for identification, which is unfailing in practice. Because of non-availability of previous records for cross matching, this technique is not of much use in India. In none of the case of present study, identity was established by fingerprinting.[9]

In present study of 100 cases, where the majority cases did not show any ante-mortem injuries over the body and none of them were positive for poisoning as confirmed by chemical analysis at Forensic Science

Laboratory. In all these cases sternum bone was preserved for diatoms test. Diatoms were detected in 40% cases in both bone marrow and sample of water from alleged place of drowning, which also showed similarity in their concentration and morphology, thus confirming death due to drowning. These findings were consistent with that of all other authors. It shows that in drowning cases diatoms test provides concrete evidence.

In 15% cases, cause of death was mechanical injuries where fatal injuries over the body were identifiable despite of changes of decomposition. Out of these 15% cases of injuries, 8% cases were of head injury, followed by 5% cases of firearm and in rest 2% cases other injuries i.e. lacerations, contusions etc. were present. Out of 5% cases of firearm injury, 3% cases were of rifled firearm and 2% cases were of shot gun firearm.

In 10% cases of poisoning, organo-phosphorus was detected in 6% cases while aluminum phosphide was detected in 4% cases.

In 5% cases death was due to coronary insufficiency which was confirmed by histopathological examination of heart. In 2% cases the ligature mark of hanging and strangulation was visible over the neck and could be examined distinctly from the changes of decomposition.

Our observation are very well supported by Modi and KrishanVij who have said that external fatal injuries are not difficult to find even in decomposed bodies whereas in cases of hanging and strangulation, the ligature mark would be apparent, even if the epidermis has peeled off.[3,4]

In one case, the death was due to electrocution and in remaining one case is of natural death in which we got the findings of lung pathology.

26% cases of present study were of negative autopsy in which gross and microscopic examination, toxicological analyses and laboratory investigation fail to reveal cause of death.

In present study, maximum numbers of cases (52%) were brought within 1-3 days after death followed by 29% cases in 3-7 days. This finding was consistent with the study of Shah et al in which 74% cases were brought within 7 days after death.

The reason behind this could be explained as during early phase of decomposition body emit foul smell as well attacked by animals and by this way it goes noticed by many people. While in cases of drowned bodies, it takes about 1-3 days to float when the sufficient gases of decomposition have developed to make it lighter and to get noticed by people.

Conclusion

Identity was established in 71% cases while 29% cases remained unidentified. Out of 71% cases, 55% cases were identified before autopsy and 16% were identified after autopsy.

Among 55% cases which were identified before autopsy, majority of cases (65.45%) were identified by *clothes and ornaments* followed by 29.09% *personal belongings* e.g pocket contents, wrist watch, mobile phone etc. and 5.46% by *tattoo marks*.

Among 16% cases which were identified after autopsy, majority of cases (56.25%) were identified by *clothes and ornaments* followed by 37.50% *DNA Fingerprinting* and 6.25% by *personal belongings* e.g pocket contents, wrist watch, mobile phone etc.

Among all cases of decomposed dead bodies, in majority of cases (68%) cause of death was unnatural while in 6% cases cause of death was natural. No cause of death could be detected in 26% cases.

Among unnatural deaths, in majority of cases (40%) cause of death was drowning followed by mechanical injuries (15%), poisoning (10%), hanging (1%), strangulation (1%) and electrocution (1%).Among 6% cases of natural death, cause of death was coronary insufficiency in 5% cases and lung pathology was in 1% cases.

In 52% cases, *time since death* was1-3 days followed by 29% cases in which time since death was 3-7 days, in 7% cases it was 1-3 weeks, in 9% cases it was 3 weeks-3 months and in 3% cases it was 3-6 months.

Reference

1. Reddy KSN. The Essentials of Forensic Medicine and Toxicology, 28th edition. Hyderabad: K Suguna Devi; 2009, 148-160.
2. Nandy A. Principles of forensic Medicine, 3rd Edition. Hyderabad: New Central Book Agency Ltd.; 2010, 262-282.
3. Mathiharan K and Patnaik AK. Modi's Medical Jurisprudence and Toxicology, 23rd Edition. New Delhi: Lexis Nexis Butterworth, India; 2009, 435-450.
4. Vij K. Textbook of Forensic Medicine and Toxicology – Principles and Practice, 4th Edition. New Delhi: Elsevier, India; 2008, 132-146.
5. Parikh CK. Parikh's Text Book of Medical Jurisprudence and Toxicology; 6th edition.
6. Spitz and Fisher's. Medico legal investigation of death, 3rd edition. 31-70.
7. Taylor's Principles and Practice of Medical Jurisprudence, 13th edition. New Delhi: Churching Livingstone; 145-155.
8. VV Pillay. Handbook of Forensic Medicine and Toxicology, 14th edition. 104-107.
9. Berry AJ Fisher. Techniques of Crime scene Investigation, 7th edition. CRC Press; 2003: 99-123.

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Correlation of Stature of Adult Individual with the Length of Clavicle

Yashoda Rani*, Shrabana K. Naik, Avnish K. Singh***, Atul Murari******

Abstract

Besides determination of race, sex, age of the unknown individual, estimation of stature enhances the reliability of identification process. It is easier to get those data when the whole body or entire skeleton is available to the forensic anthropologist. However, in cases of deliberate mutilation and disposal in parts, interference by wild animals, bomb blast by terrorist attack, recovery of the whole body or complete skeleton may not be possible. In those cases, the forensic anthropologists have to give his opinion on the available supplied material. Although approximate stature of the individual can be estimated from most of the long bones using either multiplication factors or regression formulae, only few have taken attempt to correlate stature with length of clavicle.

Keywords: Stature; Long bones; Clavicle; Estimation; Correlation.

Introduction

Estimation of stature is an essential part of identification process of unknown individuals, especially in case of situations where human bodies are found either as skeletal remains or in mutilated conditions. Approximate stature can be estimated if multiple long bones of limbs are available, but from any other single bone, it always remains a daunting task for any anthropological/forensic examiner, especially clavicle which lies horizontally in the body.In the past, Terry, Oliver, and Thieme have tried to estimate the stature of the individual from clavicle, outside India.[1-3] Similarly, in India, only few studies have been conducted so far by Singh & Sohal, Jit & Singh, Yadav and Khaka on estimation of stature from clavicles.[4-7] Considering the paucity of studies with conflicting results, the present authors have made an attempt to correlate stature of the individual from the maximum length of clavicle.

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Aims & Objectives

1. To correlate stature of individual with maximum length of clavicle.
2. To obtain the regression formulae to estimate stature from adult clavicle, for both sexes.
3. To compare reliability of maximum length of clavicle with other parameters namely, mid clavicular circumference, vertical diameter of clavicle, saggital diameter of clavicle, caliber index of clavicle, cross sectional index of clavicle and weight of clavicle, for determination of stature.

Materials & Methods

In the present study, total 100 clavicles of both sides of 70 male and 30 female individuals were taken from the dead bodies that came for medico-legal autopsies at Lady Hardinge Medical College & Smt. S.K. Hospital, New Delhi from the period Jun' 2004 to Apr' 2006.

Instruments & Equipments used

1. Calibrated autopsy table.
2. Foreceps.
3. Scalpel with blade.
4. Beakers.
5. Sodium Bicarbonates.
6. Box for keeping clavicles.
7. Osteometric board.
8. Vernier Caliper.

Method used

1. Identification of the sex of the individual.
2. Measurement of stature of the individual.
3. Removal of the clavicle from the dead body.
4. Maceration of soft tissues attached to clavicle.
5. Cleaning and drying of the clavicles.
6. Measurement of various parameters including maximum length of clavicle, initially by osteometric board, and then rechecked by vernier caliper.

Observation & Results

Table 1 shows length of the clavicles of both sides in Male individuals where as Table 2 shows length of the clavicles of both sides in Female individuals. The mean length of left clavicle was found more than the mean length of right clavicle in both the male and female individuals. In case of male subjects, the standards of errors were 5.15 for left clavicle, and 5.93 for right clavicle. Similarly, in case of female subjects, the standards of errors were 5.04 and 3.09 for left and right clavicles respectively.

When standards of errors of maximum length of clavicle were compared with standards of errors of mid clavicular circumference, vertical diameter of clavicle, saggital diameter of clavicle, caliber index of clavicle, cross sectional index of clavicle and weight of clavicle, it was observed that standards of errors of maximum length of clavicle is minimum for both male and female as well as for both left and right clavicles.

Basing on the maximum lengths of clavicles for both sexes of both sides, separate linear equations are derived. Linear regression

Table 1: Showing Length of the Clavicles of Both Sides in Male Individuals

	Left Clavicle	Right Clavicle
Total No.	33	37
Range	138.74 mm-161.29 mm	137.98 mm- 164.73 mm
Mean	149.74 mm	146.18 mm
Standard error	5.15	5.93

Table 2: Showing Length of the Clavicles of Both Sides in Female Individuals

	Left Clavicle	Right Clavicle
Total No.	17	13
Range	106 mm-137.65 mm	104.23 mm- 135.29 mm
Mean	118.44 mm	115.60 mm
Standard error	5.04	3.09

Table 3: Showing Comparison with Standards of errors of Other Parameters

Sl. No.	Parameters	Male		Female	
		Left Clavicle	Right Clavicle	Left Clavicle	Right Clavicle
1	Mid clavicular circumference	7.01	6.73	8.35	9.39
2	Vertical diameter of clavicle	6.67	6.22	8.33	9.07
3	Saggital diameter of clavicle	6.92	6.73	8.35	9.39
4	Caliber index of clavicle	7.19	6.65	8.42	8.36
5	Cross sectional index of clavicle	7.21	6.75	8.29	9.41
6	Weight of clavicle	6.92	6.65	8.12	7.26
7	**Maximum length of clavicle**	**5.15**	**5.93**	**5.04**	**3.09**

equations thus obtained are:

For male individual

46.259 + 0.790 X Maximum length of left clavicle

34.982 + 0.988 X Maximum length of right clavicle

For female individual

54.714 + 0.808 X Maximum length of left clavicle

35.082 + 0.973 X Maximum length of right clavicle

Discussion

Studies conducted by Terry, Oliver, Thieme outside India are not based on the materials from India; hence their formulae cannot be applied for Indian population. In India, few studies conducted by Singh & Sohal, Jit & Singh, Yadav and Khaka on estimation of stature from clavicles showed conflicting results.[4-7] Singh & Sohal have suggested multiplication factor for only male individuals. Thus, it cannot be applied for female individuals. Again, as there is variation in maximum length of clavicles of left and right side, same multiplication factor cannot be applied to both sides' clavicles. Yadav in Rohtak derived multiplication factor for both sides in both sexes. But he also suggested that multiplication factor is of little use in stature estimation. Khakha analyzed various parameters of clavicle of both sides of both sexes separately and also derived linear regression equation for each parameter of the clavicle. He found that maximum length was the best parameter for stature estimation from clavicle because of minimal standards of errors.

In the present study, we have also analyzed various parameters of clavicle of both sides of both sexes separately and also derived linear regression equation for each parameter of the clavicle. We found that maximum length was the best parameter for stature estimation from clavicle because of minimum standards of errors and maximum correlation coefficient, as reported by Khakha.

Conclusion

Thus, if only the clavicle is recovered, then anthropologist/forensic examiner can estimate the stature of the individual with a reasonable degree of accuracy. However, as our study is on Delhi based heterogeneous group of population, similar studies on homogenous group of population may yield better results. Out of seven parameters, maximum length of clavicle was found the best parameter to estimate the stature of unknown individual. For estimation of stature from clavicle, sex and side of the clavicle must be considered for applying the regression formula.

Regression formulae for estimating stature from the clavicle

For male individual

46.259 + 0.790 X Maximum length of left clavicle

34.982 + 0.988 X Maximum length of right clavicle

For female individual

54.714 + 0.808 X Maximum length of left clavicle

35.082 + 0.973 X Maximum length of right clavicle

N.B.: We are hereby regret the sad dismissal of Dr. Avnish Kumar Singh, the co-author.

References

1. Terry J. The clavicle of the American Negro. *American Journal of Physical Anthropology*. 1932; 16: 351-381.
2. Oliver G. Anthropologic de le Clavicle III. La claviculae du Francais. *Bull Social Anthropology*. 1951; 2: 121-157.
3. Thieme FP. Sex in Negro skeletons. *Journal of Forensic Medicine.* 1957; 4: 72-81.
4. Singh B, Sohal HS. Estimation of stature from the length of clavicle in Punjabis, a preliminary report. *Indian J Med Res*. 1952; 40: 67-71.
5. Jit I, Singh S. Estimation of stature from clavicles. Indian *J Med Res*. 1956; 44: 137-155.
6. Yadav DR. Study of adult clavicles for determination of sex and stature in Rohtak (Haryana). Thesis for MD (Forensic Medicine), Maharishi Dayanand University, Rohtak, 1980.
7. Khakha AF. Status of adult clavicle for determination of sex and stature in Delhi. Thesis for MD (Forensic Medicine), UCMS, Delhi, 1989.

Sexing Ulna by Multivariate Analysis

Dope Santoshkumar A.*, Gaikwad Jyoti R., Selukar Mangesh S.***, C.V. Diwan******

Abstract

Sex identification from skeletal remain has great medicolegal and anthropological significance.A number of studies are available in this regard. The studies being population specific and in general are of not universal help. Present study is an attempt to establish multivariate analysis of ulna for the determination of sex. Materials & Methods used as 193 adult human ulnae, 133 male and 60 female from the Bone Bank of Govt. Medical College Aurangabad, were used for the present study. Four different Parameters of ulnae were studied for making two groups and multivariate analysis of ulnae done for sex determination. SPSS (Sum of products and Sum of Squares) is used for applying multivariate linear discriminant analysis and a discriminant functional score is obtained. Any ulna falling on the male side of the sectioning point will be categorized as male ulna while that falling on female side of sectioning point will be categorized as female ulna. This enhances the accuracy of opinion.

Conclusion of study is Multivariate analysis of long bones including ulnae are of immense help in determination of sex of deceased person specially in cases where skeletal remains available are very less.

Keywords: Forensic anthropology; Sexual dimorphism; Multivariate analysis; SPSS; Sectioning point; Skeletal collection.

Introduction

Traditional non metrical methods for sex determination from various parts of skeleton depend on expert's ability and experience – factors which can seldom be evaluated objectively & accurately.

Recently a new approach to the old problem of sexing has developed which is concerned with presenting multivariate discriminant function technique based on various measurements of bones. Various studies based on multivariate discriminant analysis for sexing skull[1,2], teeth[3], mandible[4], scapula[2] , sacrum[5], pelvis[6], femur[7], tibia[8] and other bones of the body.

As a general rule definitive sexual traits in the skeleton do not manifest until after the full achievement of the secondary sexual traits that appear during puberty. The dividing line between immaturity and maturity is somewhere around 15-18 years. Prior to this age sexing the bones has been inconclusive. Hence the description of the sex differences is to be limited to the ages above 18 years.

The Ulna is a medial bone of the forearm and is parallel with the radius when the arm is supine. It articulates with the humerus at their proximal end and bones of wrist at their distal end. It has a large hook like articular surface on the proximal end and the somewhat angular shaft decreases in size to the rounded head and styloid process of the distal end.

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Various parameters of were studied for sexing ulna by multivariate analysis and compare the study with other studies carried out on ulnae.

Aims and Objectives

Aim of present study is to achieve the highest possible accuracy in establishing sex from ulna with the available resources.

The study is done with the following objectives:

1. To study the metrical data of adult male and female ulna.
2. To study the usefulness of various parameters and indices of ulna for sex determination.
3. To study the overlap in the observed values.
4. To derive a multivariate formula which will help us in establishing sex from ulna.
5. To compare the results of multivariate analysis with that of univariate analysis.

Materials & Methods

193 Adult human ulnae of known sex available in the Bone Bank of the Department of Anatomy, Government Medical College, Aurangabad are used for the present study.

Out of 193 ulnae, 60 are of females and 133 of males. All the ulnae are dry, free of damage or deformity and are fully ossified. The personal records of all the ulnae for age, sex & race are available with the Bone Bank.

The instruments which are used for the measurements of various parameters of ulna are as follows:

1. Scale.
2. Osteometer.
3. Sliding vernier Calliper.
4. Standardized flexible Steel tape.
5. Threads, marker pencils & pens.

Following measurements are taken for each ulna:

1. Total Length (L)

Total length from top of olecranon process to tip of styloid, measured parallel to the shaft, this is achieved by applying top of olecranon to osteometer wall and the sliding pointer is used to mark the tip of styloid.

2. Proximal ulnar width (PWD)

The maximum breadth of the upper end of ulna, it is measured by the vernier caliper.

3. Coronoid height (CH)

The maximum anterioposterior distance between the coronoid process and the posterior surface of the shaft taken perpendicular to the shaft axis.

4. Distal width (DWD)

The maximum breadth of the distal articular surface excluding the styloid process.

All measurements are recorded in mms.

A standard computer program, prepared according to "multivariate linear discriminant function" as proposed by armitage (1971) is used. The principle of "multivariate linear discriminant function" is that measured variables are taken as independent variables where as sex is a dependent variable. The measured variables are then analyzed by standard computer program and a discriminant functional score is obtained. This is done by the computer by summing the independent variables after weighing each of them by an appropriate co-efficient.

The formula is:

$Z = b_0 + b_1 x_1 + b_1 x_2 + -- b_{18} X_{18}$

(Where Z is discriminant functional score & b_0 is constant

$b_1 b_2 + -- b_{18}$ are coefficients and $x_1 x_2$ –

— — x_{18} are variables of parameters)

A few variables which are found statistically insignificant by routine statistical methods enhance the values of statistically significant variables in a multivariate analysis.

A mean functional score for males (Z_m) is obtained by subjecting mean values of all variables of males to discriminant function.

Similarly (Z_f) mean functional score for females is also obtained.

The arithmetic mean of the mean values of males and females when put in place of variables in the formula gives the sectioning point (Z_0)

Any ulna falling on the male side of the sectioning point Z_0 will be categorized as male ulna while that falling on female side of Z_0 will be categorized as female ulna. This enhances the accuracy of opinion.

Results

One hundred and ninety three ulnae of known sex available in Bone Bank of the Department of Anatomy, Government Medical College, Aurangabad, are studied and various dimensions are measured.

Multivariate linear discriminant analysis is applied to the data by selecting variable in groups and linear functions are obtained for each of them.

The differential functional score is designated as C for Group I variables, the values of C_m, C_f and C_o are calculated and subsequently for group II the differential functional score is designated as D, the values of D_m, D_f and D_o are calculated and then the respective ulnae are scored and categorized as male and female on the basis of their score.

All the ulnae are then analyzed by making use of differential functional scores of two groups of variables and the accuracy of sorting of each group of male, female and overall is calculated.

"Multivariate linear discriminant analysis" is applied to two sets of variables designated as group I, group II respectively, and their respective discriminant functional scores designated as C, & D respectively.

The variables of group I are

1. Total length.
2. Coronoid height.
3. Distal width.

The constant and co-efficient obtained are:

c_0=3.899, c_1=0.111 , c_2=0.632, c_3=0.012

The values of discriminant functional score calculated are designed as C, the respective values are:

C_m=54.99474, C_f=49.82462, C_0=52.40968

The discriminant functional score of each ulna is calculated on the basis of these variables and compared with C_0.

The variables of group II are:

1. Total length.
2. Proximal width.
3. Distal width.

The constant and co-efficients obtained are:

d_0=6.926, d_1=0.270, d_2=0.358, d_3-=0.080

The values of discriminant functional score calculated are designed as D, the respective values are:

Table 1: Percentage of ulnae accurately sexed by multivariate analysis

	Group I		Group II	
	Male	Female	Male	Female
Total No. of bones	133	60	133	60
No of bones identified	115	49	114	48
Percentage of accuracy	86.5%	81.7%	86%	80%
Overall no of bones identified out of 193	164		162	
Overall percentage of accuracy	84.97%		83.93%	

D_m=81.16122, D_f=74.27838, D_0=77.7198

The discriminant functional score of each ulna is calculated on the basis of these variables and compared with D_0.

Discussion

For multivariate linear discriminant analysis two groups of variables are made and separately analyzed.

Group I

Linear regression analysis of the same parameters which was done by Steel i.e. group I consisting of :

1. Total length.
2. Coronoid height.
3. Distal width is done.

Present study is compared with the study of Steel[9] (1972). Discriminant functional score less than the sectioning point classify as female and more than the sectioning poing classify as male by Steel.

Although the co-efficients and sectioning discriminant functional scores vary in the two studies. The difference in co-efficients obtained may be attributed to racial differences and number of bones studied. Steel[9] studied, 27 males and 33 females ulnae in England population. Whereas the present study is on population of Marathwada region of Maharashtra (India) and 133 males & 60 females ulnae are studied.

Table 2: Comparison of co-efficients of Steel and group I of present study

No of bones	Steel[9] M = 27 F = 33	Present study M = 133 F = 60
Constant	Zero	3.899
Total length	1	0.111
Coronoid height	0.9533	0.632
Distal width	0.4193	0.012
Dfs	634.50	52.40968

Where Dfs = Discriminant functional score

Table 3: Comparison of co-efficients and accuracies of Mall G. and present study group II

No of Bones Studied	Mall G[10] M = 64 F = 79	Present study M = 133 F = 60
Total length	0.552	0.270
Proximal width	0.337	0.358
Distal width	2.909	0.080
Sectioning point (dfs)	M $\geq$ 0.30 F $\leq$ 0.30	M > 77.7198 F < 77.7198
Accuracy	Overall = 90.58%	M= 86%, F = 80% Overall = 83.93%

Group II

Group II is made of the same parameters used by Mall G[10] (2001) i.e.

1. Total length.
2. Proximal ulnar width.
3. Distal width.

Present study is compared with the study of Mall G[10] (2001) the above table shows the details of two studies i.e. number of bones used, co-efficients obtained, sectioning discriminant functional scores, accuracies etc.

The earlier study is carried on German population, whereas the present study is on Indian race of Marathwada region.There is difference in the number of bones used and variation in the race of the present and the earlier study of Mall G.[10] This can explain the slight difference seen in the individual accuracies of male and female of the two studies.

Form the two groups it is observed that accuracies of both groups are nearer (approximately 85%-90%) and the simplest group is of group I which can be easy to use on large population.

Table 4: Accuracy found by multivariate analysis by previous workers and present study

Name of workers	Accuracy found		
	Male	Female	Overall
Introna F Jr.[12] (1993)	-	-	95%
Mall G. *et al*[10] (2001)	-	-	90.58%
Purkait R[11] (2001)	95%	83.3%	90.6%
Present study	86.25%	80.85%	83.55%

A comparison of the overall accuracies obtained by different workers in the determination of sex from ulna by multivariate analysis is shown in the following Table.

Summary and Conclusion

The multivariate analysis is applied to two groups of the parameters. The variable selected for group I are Total length, Coronoid height & Distal width and for group II are Total length, Proximal width & Distal width, all statistically significant. Sorting of ulnae can be increased by applying multivariate analysis. With group I variables, the individual male and female accuracy is 86.5% and 81.7% respectively. While with group II variables, the individual male and female accuracy is 86% and 80% respectively. Overall accuracy is being 84.97% in group I and 83.93 % in group II. Total number of ulnae sexed accurately by group I is 164 and group II is 162 out of 194.

It is obvious that results obtained in the present study are lesser as compared to other workers.

Difference in percentage of accuracies in different studies depend on number of bones used and racial variation

From the results of multivariate analysis we can conclude that:

1. Even if only ulna of the deceased is available, present study can determine the sex of the deceased person accurately by applying multivariate analysis in as many as 86% of cases.
2. Linear regression is far better than any of the independent variables used alone.
3. On comparing the results of group I, group II it is seen that, changing the combination of parameters does influence the percentage of ulna identified with total certainty.
4. Multivariate analysis is the best method for determination of sex of ulna with the available resources.
5. Sorting percentage can be increased by using more parameters for multivariate analysis.

On comparing the results of multivariate analysis with univariate analysis it can easily be seen that the accuracy obtained by multivariate analysis is much better than that of the univariate analysis.

References

1. Song H Lin Z, Jin J. Sex diagnosis of Chinese skulls Using multiple stepwise discriminant function analysis. *Forensic Sci Int*. 1992; 54: 135-140.
2. Hanihara N. Sex diagnosis of Japanese skulls and scapulas by means of discriminant function analysis. *Journal of Anthropological Society of Kippona*. 1959; 67(722): 21-27.
3. Hanihara K. Sexing of Japnese Skeleton teeth by discriminant function method. *J Anthropol Soc Nippon*. 1981; 89: 401-418.
4. Giles E. sex determination by discriminant function analysis of the mandible. *Am J Phys Anthrop*. 1964; 22: 129-132.
5. Flander LB. Univariate and Multivariate methods for sexing the Sacrum. *Am J Phys Anthrop*. 1978; 49: 103-110.
6. Schulter Ellis FP, Schmidt DJ, Hayek LA, Graig J. Determination of sex with a discriminant analysis of new pelvic bone measurements: Part I. *J Forensic Science*. 1983; 28(1): 169-80.
7. Trancho GJ, Robiedo B, Lopez Bueis L, Sanchez JA. Sexual determination of the femur using discriminant functions analysis of the Spanish population of known sex and age. *J Forensic Sci*. 1997; 42(2): 181–5.
8. Zheng T, Pang T. Determination of sex from the tibia by the stepwise discriminatory analysis. *Acta Anthropol Sinica*. [Chinese with English abstract].
9. Steel FLD. The sexing of long bones with reference to St. Brides Series of identified Skeletons. *J Royal Anthrop Inst*. 1972; 92: 212-222.
10. Mall G, Hubig M, Buttner A, Kuzhik J, Penning R, Graw M. Sex determination and estimation of stature, from the long bones of the arm. *Forensic Sci Int*. 2001; 117(1-2): 23-30.

11. Purkait R. Measurements of ulna – a new method for determination of sex. *J Forensic Sci J41*. 2001; 46(4): 924-927.
12. Introna F Jr, Dragone M, Frassanito P, Colonna M. Determination of skeletal sex using discriminant analysis of ulnar measurements. *Boll Soc Ital Biol*. 1993; 69(9): 517-23.
13. Ding S, Ren D Fa, X Yan, Lai X. Sexual diagnosis of Chinese crania from discriminant function analysis. *Can Soc Forensic Sci J*. 1992; 22: 119-112.
14. Dittrick J, Suchey JM. Sex determination of pre historic central California skeletal remains using discriminant analysis of the femur and humerus. *Am J Phys Anthropol*. 1986; 70(1): 3-9.
15. Giles E Elliot. Sex determination by discriminant function analysis of crania. *Amr J Phys Anthrop*. 1963; 21: 53-68.

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Original Article

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A Study of Weights of Vital Intracranial, Thoracic and Abdominal Viscera and Correlation of it with Bodyweight in Different Age-Group of Deceased in Fatal Medico Legal Cases at a Medical Institute of Central India

P.N. Murkey*, B.H. Tirpude, Biprojit Debbarma*****

Abstract: This study is a prospective examination of total 303 (201 males, 102 females) autopsy cases ranging from one day to 90 years during the period from 1st July 2009 to 31st June 2011 in the Department of Forensic Medicine and Toxicology of a Medical Institute of central India. Measurements are taken of organs (in gram unit) of Brain, Heart, Lungs, Liver, Spleen, Kidneys, and body weight taken (in kilogram unit) of the dead bodies. All fire related death, cases of decomposition and those who showed any macroscopic evidence of disease on gross autopsy are excluded. In this study, weight of the organs at all age groups is lower when compared with Western and North Indian population because they are hefty and taller than the central Indian population. Weight of organs in females is less than males at all ages except lungs at age group 61- 70 years (654.3 in female & 539.9 in males), liver at age group 21-30 years (1289.4 in females &1268.3 in males) & spleen at age group 21-30 (118.3 in male & 122.9 in females) and 41-50 years (112.3 in male & 128.7 in females). In this study the weight of all internal organs has been seen categorically increased in the age group of 61-70 years but shows a decline immediately after 70 years of age due to catabolic activity and old debilitating changes at this age.

Keywords: Vital organ weights; Prostate weight; Medico legal autopsy.

Introduction

Growth and development are the fundamental property of life, being the normal function of every individual, the growth of viscera of body proceeds along with the physical development of human being. Growth of different parts of the body follows a predictable schedule during normal development and maturation. The development not only is influenced & controlled by many genetic, environmental factors but it is also dependent on race, body weight, length, age, sex, habitat, habits, climatic conditions, diet, nutrition, environment and socioeconomic status of an individual. As India being a vast country, there are multiple factors like climate, nutrition and tropical diseases which vary from South to North and from East to West, which play an important role for gaining organ weight as compared to Foreign Countries.

From the previous studies, it was found that there is marked variation in weight of organs and body weight and stature in different races. Hence, present study will be carried out to see such variations in Central Indian people and their comparison with other races. Not only application of such anatomical knowledge will explore different types of influences like- age, sex, nutrition, race, on human body that may again help in formation of concept of such variations in different countries or at different states or areas of a single country.

Materials and Method

This study is a prospective examination of total 303 (201 males, 102 females) autopsy

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cases ranging from one day to 90 years during the period from 1st July 2009 to 31st June 2011 in the Department of Forensic Medicine and Toxicology of a Medical Institute of central India. Measurements of organs (in gram unit) of Brain, Heart, Lungs, Liver, Spleen, Kidneys, Uterus, Prostate, and body weight taken (in kilogram unit) of the dead bodies. The Body length (or height) was measured from the head to the heel by standard foldable measuring metal caliper. All the bodies were weighed naked with the same weighing machine by a standard Electronic machine. All autopsies were performed within 24-36 hours after death to avoid altered organ weights. Besides the age is spread into nine groups. All fire related death, cases of decomposition and those who showed any macroscopic evidence of disease on gross autopsy are excluded. Organs are removed by Virchow's method and weighed on standard Electronic machine. The data of organ weight were statistically analyzed.

Table No 1: Organs weight at different ages of life in Male

Age Groups	Brain			R.Lung			L. Lung			Heart		
	No. of cases	Mean	Range	No. of cases	Mean	Range	No. of cases	Mean	Range	No. of cases	Mean	Range
0-10	10	766.4	240-1153	9	156	56- 314	9	132.78	34-304	10	78	10-159
11-20	12	1209	900-1426	12	439.917	300-540	12	420.750	260-493	12	196.667	90-300
21-30	44	1254.318	875-1496	44	458.500	211-768	44	422.182	208-710	45	217.511	175-303
31-40	42	1268.143	925-1600	38	462.711	265-850	38	425.533	223-750	42	210.714	169-300
41-50	24	1238.542	996-1575	25	451.920	300-816	25	414.240	250-594	22	223.636	187-300
51- 60	29	1262.276	971-1450	24	444.458	280-800	24	412.125	241-700	21	224.667	182-270
61-70	22	1246.500	972-1450	20	539.900	340-780	22	516.591	236-750	16	231.625	194-281
71-80	12	1208.083	1000-1480	10	405	189-591	10	374.800	191-582	9	238.444	192-370
81-90	04	1198	1096-1480	04	465.250	371-550	04	405.750	288-496	02	236.500	181-292
Total cases	**199**			**186**			**188**			**179**		

Continued....Table 1 : Organs weight at different ages of life in Male

Age Groups	R. Kidney			L. Kidney			Liver			Spleen		
	No. of cases	Mean	Range	No. of cases	Mean	Range	No. of cases	Mean	Range	No. of cases	Mean	Range
0-10	10	50.6	23-72	10	44.6	23-64	10	456.9	71- 884	10	54.5	5-112
11-20	12	109.333	75-160	12	104.417	74-160	12	1286.917	1000-1526	12	94.250	40-180
21-30	45	123.978	90-160	45	116.311	80-150	44	1268.363	1026-1566	44	118.364	80-300
31-40	42	126.286	78-180	42	121.095	73-180	42	1255.214	726-1692	42	133.143	80-253
41-50	25	124.560	90-200	25	121.200	80-200	25	1286.400	1100-1442	25	112.320	80-210
51- 60	29	121.138	73-163	29	117.448	72-200	29	1280.655	850-1450	29	128.448	35-250
61-70	22	130.591	98-170	22	122.682	88-160	22	1288.318	800-1400	22	133.364	55-234
71-80	12	116.917	68-190	12	118.250	81-200	12	1202.333	725-1475	12	119.167	38-210
81-90	04	114	96-120	04	104.750	83-116	04	1255.750	979-1425	04	105.500	88-151
Total cases	**201**			**201**			**200**			**200**		

Table 2: Organs weight at different ages of life in Female

Age Groups	Brain			R.Lung			L. Lung			Heart		
	No. of cases	Mean	Range	No. of cases	Mean	Range	No. of cases	Mean	Range	No. of cases	Mean	Range
0-10	10	542.8	250-1129	11	134.09	24- 246	11	127.09	24- 248	11	71.636	10- 148
11-20	23	1181.261	912-1430	22	413.591	175-789	22	397.182	160-756	24	195.250	90-300
21-30	20	1233.650	900-1456	18	443.500	190-669	18	426.778	160-658	18	211.833	180-293
31-40	14	1135.857	830-1450	13	447.231	250-685	13	414.692	220-670	14	209.071	144-250
41-50	17	1212.529	900-1450	17	418.235	200-793	17	403.176	200-691	15	215.600	150-300
51- 60	08	1224.625	1080-1375	09	435.778	295-684	09	372.111	215-650	08	220	204-250
61-70	04	1218.500	1060-1325	03	654.333	523-790	03	627	521-730	03	230.333	210-260
71-80	03	908	759-1029	03	415.333	369-475	03	352.667	277-405	03	234.667	216-256
81-90	0	542.8	250-1129	-	134.09	24- 246		–	–		–	–
Total cases	99			96			96			96		

Continued....Table No 2: Organs weight at different ages of life in Female

Age Groups	R. Kidney			L. Kidney			Liver			Spleen		
	No. of cases	Mean	Range	No. of cases	Mean	Range	No. of cases	Mean	Range	No. of cases	Mean	Range
0-10	11	47.273	8-92	11	44	8-85	11	401	80- 1000	11	43.27	6- 112
11-20	24	106.792	40-140	24	103.167	40-150	24	1191.875	864-1456	24	93.708	40-150
21-30	20	120.900	55-150	20	115.200	54-147	20	1289.450	900-1668	20	122.900	50-206
31-40	14	119.143	74-200	14	114.643	71-230	14	1225.571	980-1480	13	120.00	82-220
41-50	17	123.882	86-140	17	117.647	71-136	17	1272.647	900-1600	17	128.765	60-300
51- 60	09	106.000	60-135	09	109.556	50-210	09	1272.556	926-1500	09	117.444	62-210
61-70	04	122.750	109-150	04	119.500	90-142	04	1250.000	1060-1329	04	135.250	92-195
71-80	03	98.000	81-130	03	92.333	76-122	03	991.667	754-1125	03	77.000	51-99
81-90	-	--	–		--	--		–	–	-	–	–
Total cases	102			102			102			101		

Observation

Discussion

The organ wise weights at different age groups are compared and discussed below with various authors.

Brain

Batra A. K. *et al* (1995) and Singh Dalbir *et al* (2004) mentioned that mean brain’s weight in 0-10 years is 856 gm, 1098.24 gm in male which becomes 1240 gm, 1315.13 at age group 11-20 years which is 10.46%, 30.21% and 2.5%, 8.06% more than present study respectively. The maximum brain's weight is seen in age group of 31-40 in males mean brain's weight is 1254, 1336.85 gm in Batra A K and Singh Dalbir study and in the present study it is 1268.14 gm. In the female, maximum brain's weight seen at age group 11-20 years (mean brain's weight -1132gm) in Batra A.K. and 1210.21 gm, in Singh Dalbir *et al*. at the age group of 21-30 years. In the present study maximum mean brain's weight is 1268.14gm which is also same as Singh Dalbir study. Piyanun M. *et al* (2009) observed that mean brain's weights 1358.8 gm which is 12.3% more than present study at age group 11-20 yrs. After that it remains almost constant till age group 41-50 yrs where mean brain's weight is 1311.04 which are again 6.3% more than present study. At the old age there is decreased in the mean brain's weight in all the three studies in both sexes.

Lungs

Batra A. K. *et al* (2002) mentioned in male that mean Right lung's weight in 0-10 years is 101 gm, which becomes 266 gm, at age group 11-20 years which is 54.45% and 65.38% less than present study. Singh Dalbir *et al* (2004) observed 149.32 gm which become 444.92gm which is 4.33 and 1.12% more than present study. Batra A. K. *et al* (2002) mentioned that mean Left lung's weight 0-10 years is 96 gm in male and 95 in female, which becomes 254-220 gm, at age group 11-20 years which is 38.31%, 33.77%, 65.65% and 80.53% less than present study respectively. Singh Dalbir *et al* (2004) observed left lung's mean weight as 143.42 gm, 137.96 becomes 411.51 gm which is 370.04 gm in male and female respectively which is 7.41%, 7.8% more and 2.24% and 7.37% less than the present study.

Piyanun M. *et al* (2009) observed that lung's mean weight is 791.5 gm which are significantly higher than present study of both lung means 454.1 and 423.5 respectively at age group 21-30 yrs. At older age group 61-89 yrs of Piyanun, lung mean weight 766.6 gm is decreased which is similar with present study of both right lung and left lung mean lung's weight 407.3 and 369.6 respectively at age group 71-80 yrs.

Heart

Batra A. K. *et al* (2002) study is 256gm, 224 gm which is 45.28 % and 14.92% more than the present study in male and female (31-40 years) respectively. Singh Dalbir *et al* study is 301.68gm , 251.98 gm which is 30.15%%, 17.02% more in male and female respectively than the present study (31-40 years). Piyanun M. *et al*(2009) observed that mean heart weight is 267.95 gm which are 26.95% higher than present study of at age group 11-20 yrs. Heart weight increased exponentially till old age in both sexes due to deposition of epicardial fact and cardio myopathy.

Kidneys

Batra A. K. *et al* (2002) mentioned in male that mean Right kidney's weight 0-10 years is 30 gm and in female 25 gm which becomes 113 gm, and 86 gm at age group 11-20 years which is 68.66% and 89.9%, 10.97%,34.9% less than present study. Singh Dalbir *et al* (2004) study shows right kidney's weight as 52.92 gm in males and 58.66 gm in female which becomes 114.20gm. in male , 114.99 gm in female and which is 4.38%, 19.4% 4.26, 7.12% more than present study. Right kidney's weight increased exponentially till the age group of 31-40 years in both sexes except in female it is still 21-30 years in female and present study. Maximum right kidney mean is seen at age 31-40 years age group in Singh Dalbir, above 40 years in Batra AK study and at 61-70 age groups in present study. Piyanun M. *et al* (2009) observed that mean kidney weight is 236.5 gm which are significantly higher than present study of both kidney means 107.6 and 103.0 respectively at age group 11-20 yrs.

Liver

Piyanun M. *et al*(2009) observed that mean liver's weights 1297.5 gm which is 5.7% more than present study at age group 11-20 years. At age group 41-50 years mean liver's weight is 1489.0 which are again 13.92% more than present study (1281.6 gm). At old age group 61-89 years in Piyanun study, liver's mean weight is decreased which is similar with present study. At age group 71-80 yrs. Batra A. K. *et al* (2002) mentioned mean liver's weight 497, & 405 gm in males and female at age 0-10 years which becomes 1258 gm, & 1087 gm at age group 11-20 years which is 8.06%, 0.98%, 0.22% more and 12.74% less than present study respectively. Singh Dalbir *et al* (2004) mentioned mean liver's weight 619.73 gm in males and in female 498 gm at age 0-10 years which becomes 1420.62 gm, 1282.86 gm at age group 11-20 years which is 26.27%, 19.47%, 9.41% more and 2.09% more than present study respectively. Internal organ weight decreased at the age group at more than 60 years in Singh Dalbir study and more than 40 years in Batra A K and more than 71-80 years in present study.

Spleen

Batra A. K. *et al* (2002) mentioned mean spleen's weight 59 gm in males and in female 60 gm at age 0-10 years which becomes 113 gm, 100 gm at age group 11-20 years which is 7.62%, 27.88%, 16.59% and 6.29% more than present study respectively. Singh Dalbir *et al* (2004) study shows mean spleen's weight 57.97 gm in males and in female 51.75 gm at age 0-10 years which becomes 130.05 gm, 129.35 gm at age group 11-20 years which is 5.98%, 47.07%, 27.62% and 27.35% more than present study respectively. Internal organ weight is more in female at age group 41-50 years in present study. However female heart is heavier at age group 0-10 and 11-20 years. Internal organ weight decreased at the age group at 71-80 years in present study and above 60 in Singh Dalbir study and more than 40 years in Batra A K study. Piyanun M. *et al*(2009) observed that mean spleen's weights 104 gm which are almost similar with present study mean 93.8 gm at age group 11-20 years. At age group 21-40 years mean spleen's weight is 199.2 which are again 39.8% more than present study (mean weight 1197 gm). At old age group 61-89 years in study of Piyanun, liver mean weight is decreased which is similar with present study at age group 71-80 yrs.

Conclusion

Weight of the organs at all age groups is lower when compared with Western and North Indian population because they are hefty and taller than the central Indian population. Hence studies of European and Western authors can not be taken as standard by forensic pathologist of this region. Weight of organs in females is less than males at all ages except lungs at age group 61- 70 years, liver at age group 21-30 years and spleen at age group 21-30 and 41-50 years. In this study the weight of all internal organs has been seen categorically increased in the age group of 61-70 years but shows a decline immediately after 70 years of age due to catabolic activity and old debilitating changes at this age, being heavier than females and males have more body weight and length than females.

The different results for the same are because of the nutritional status in females is different as compared to males due to typical dietary habits, cultural habits, and customs. They sacrifice more by eating less after completion of meals of male and children in his family. Also low socioeconomic status of this region together with higher incidence of maternal mortality rate because of poor dietary intake (mostly vegetarian at this region). Less birth spacing due to higher illiteracy rate in this region. These are all compounding factors that are responsible for low internal organ weight of this study.

References

1. Batra AK, Dongree AP, Mohanty AC. A Study of organ weights from Persons who died in accidents in Nagpur Dist. Of Maharashtra State. *JFMT*. 2002; 19(1): 21-24.
2. Chourasia's B D, 5th Edition. 2010; 2: 403-405.
3. Chrzanowska G, Krechowiecki A, Does the weight of the brain depend on the body height? *Gegenbaurs Morphol Jahrb*. 1975; 121(2): 192-208.
4. Daisy Sahni, Indar Jit, Lavina Sodhi. Weight and measurements of kidneys in northwest Indian adults. *American Journal of Human Biology*. 1982; 13(6): 726–732.
5. Daniel Ferreira da Cunha, Selma Freire de Carvalho da Cunha, Marlene Antônia dos Reis, Vicente de Paula Antunes Teixeira, Arquivos Brasileiros de Cardiologia, Arq Bras. Weight and Heart Weight/Body Weight Coefficient in Malnourished. *Adults Cardiol*. 2002; 78(4): São Paulo Apr.
6. Gradwohl RBH. Clinical and Laboratory methods and diagnosis. VoL II edition 4. Mod

by St Louis; 1948.

7. Gray. In Grays Anatomy 27th edition. Edited by Williams P L Roger W, M Dyson. New York-254, 260: Churchill Livingstone; 1989, 1440-1442.
8. Gur RC, Mozley PD *et al*. Gender differences in age effect on brain atrophy measured by MRI. *Proc Nat Acad Sci USA*. 1991; 88(7): 2845-49.
9. Jain SC, Mehta SC, Dogra TD, Chandrashakher N, Reddy AR, Naagaratnam A. Organ Weighs in Autopsy Cases from an Urban Apex Hospital. *Indian Journal of Medical Research*. 1992; 96: 37-44.
10. Michael T Sheaff, Deborah J Hopstar. Post mortem Technique Handbook. 2nd Edition. 2004; 80: 97-105.
11. Piyanun Mathuramon, Thamrong Chirachariyavej, AVM Vichan Peonim, Mana Rochanawutanon. Correlation of Internal Organ Weight with Body Weight and Length in Normal Thai Adults. *J Med Assoc Thai*. 2009; 92(2): 250-8.
12. Singh Dalbir, Bansal Sreenivas, Avadh Naresh Pandey, Seema Tyagi. Weights of Human Organs at autopsy in Chandigarh Zone of North West India. *JIAFM*. 2004; 26(3).

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Biomechanical Analysis of Rapid Maxillary Expansion in Adult Human Skull

Baldawa Rahul Shyamsunder*, Bhad Wasundhara Ashok**

Abstract

Objectives: To evaluate the biomechanical effects of rapid maxillary expansion (RME) on the craniofacial complex as applied to three-dimensional model of an adult human skull using the finite element method.

Materials & Methods: A 3-dimensional FEM of the craniofacial complex was developed from sequential computed tomography scan images by using the MIMICS software (version 8.0, Materialise, Leuven, Belgium) and ANSYS software (version 8.0). Known transversal (X) displacement with magnitudes of 1 mm, 3 mm and 5 mm were applied on the maxillary canine and first molar crown. The displacement and von-Mises stresses in different planes were studied on different nodes located at various structures of the craniofacial complex.

Results: Transverse orthopedic forces not only produced an expansive force at the intermaxillary suture but also high forces on various structures of the craniofacial complex, particularly at the base of the sphenoid bone and frontal process of the zygomatic bone. Lateral bending of the free ends of the pterygoid plates were noted, with increased resistance demonstrated in superior parts attached to the cranial base.

Conclusion: RME must be used judiciously in adults because of its far – reaching effects involving heavy stresses being noted at the sphenoid bone, zygomatic bone, nasal bone and their adjacent sutures.

Keywords: Adult; Biomechanical effect; Craniofacial complex; Finite element method; Rapid maxillary expansion.

Introduction

Interest in use of rapid maxillary expansion (RME) in adult patients has increased markedly during the past 2 decades. The correction of transverse discrepancies and the gain in arch perimeter as a potential non extraction technique appear to be the most important reasons underlying this increased interest.[1] Although the major treatment effect is noticed clinically in the area of the dentition, transverse enlargement of the apical base or the skeletal structures throughout the nasomaxillary complex occur simultaneously.

The review by Bishara and Staley[2] and the orthodontic texts by Proffit[3] as well as by McNamara and Brudon[4], all state that the feasibility of palatal expansion beyond the late teens and early twenties is questionable.

In order to overcome the resistance of the adult sutures to expansion, “surgically assisted” rapid maxillary expansion (SA-RME) has been advocated. SA-RME procedures have traditionally been thought to have a low morbidity, but this surgery is not free of risks, and it behooves surgeons to be aware of its potential complications.

In view of the negative outlook for successful nonsurgical palatal expansion in adult patients and concerns about the potential complications and hazards of surgical procedure, it seemed appropriate to evaluate the biomechanical effects of

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nonsurgical RME in adults.

This paper aims at investigating the biomechanical effects of RME on the craniofacial complex as applied to a three-dimensional model of an adult human skull. Within this context, the objectives of this study are:

1. To construct an anatomically accurate three-dimensional finite element model of the craniofacial complex of an adult human.

Figure 1: Dried adult human skull used in this study

2. To apply simulated displacement to the model, to know the structures involved and quantify the resultant stresses within the craniofacial complex, and to discuss the relationship of these stresses to the induced biological phenomenon.
3. To investigate the hypothesis that when RME is undertaken, the anatomical structures and the sutures of the nasomaxillary complex influence the force necessary and the manner in which the maxillae open.

Material and Methods

The analytical model in this study was developed from a dry human skull of an adult female (Fig 1) with an approximate age of 20 years, selected from the anatomic collection.

Previous studies[5] have used photographs of cross-sections of skull. In the present study, CT scan images of the skull excluding the mandible were taken in the axial direction, parallel to the Frankfort horizontal plane. Sequential CT images were taken at 1mm intervals to reproduce finer and detailed aspects of the geometry (Fig 2). This spacing

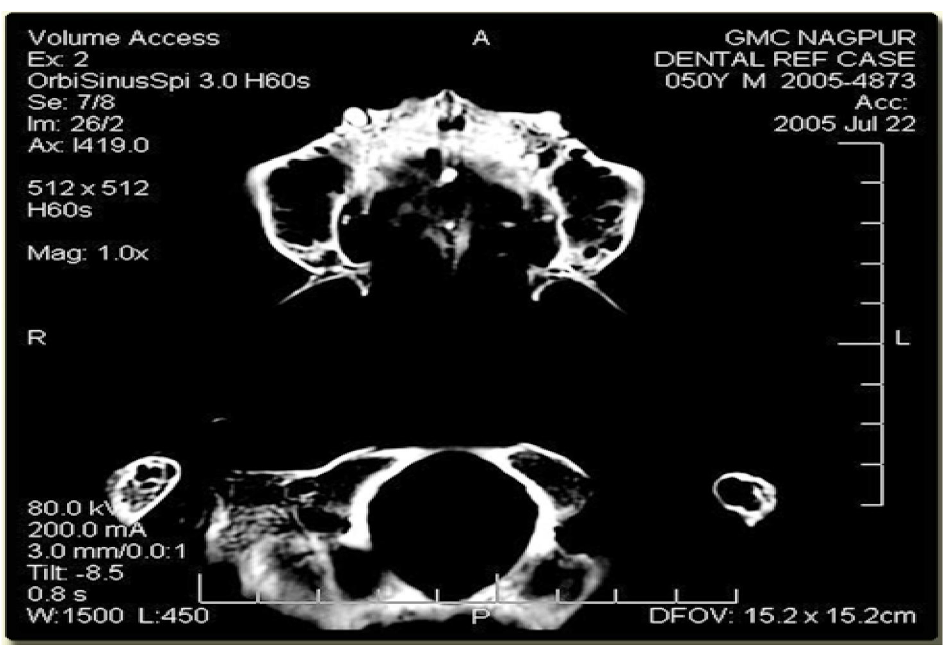
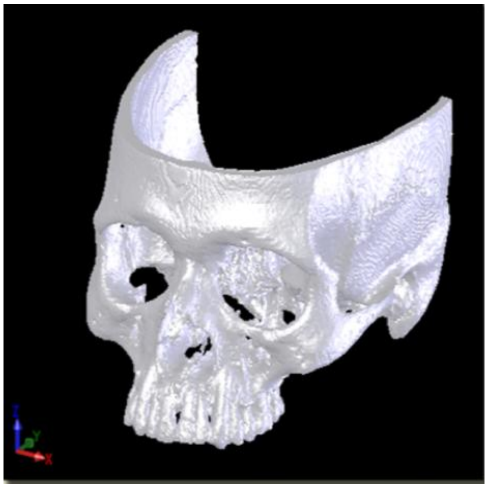
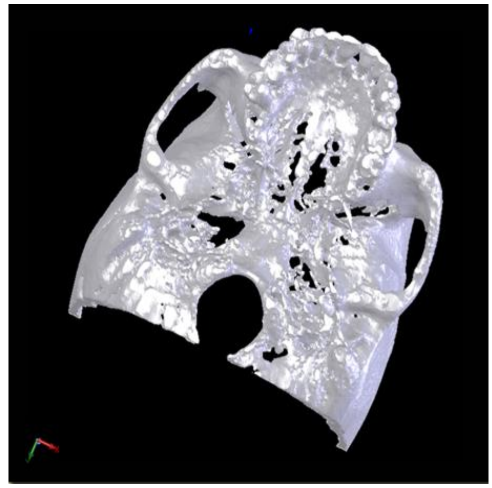


Figure 2: Sample CT slices

Figure 3 A, B: Different views of 3-D reconstruction of CT scans of skull





of CT-images enabled a higher geometric accuracy than that used by Jafari *et al* (2003; 5 mm)[6]; Iseri *et al* (1998; 5 mm)[7] and Tanne *et al* (1989; 10mm).[5]

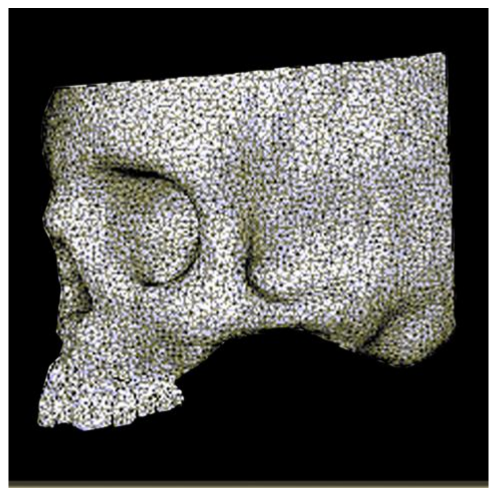
The CT scan images were read into visualization software – MIMICS. Materialise's Interactive Medical Image Control System (MIMICS) is an interactive tool for the visualization and segmentation of CT images as well as MRI images and 3D rendering of objects (Fig 3A, B). In this model, Tet 10 solid elements (10 noded) were used. The model consisted of 7,13,009 nodes and 3,57,425 Tet 10 elements (Fig 4**).**

The materials in the analysis were assumed to be linearly elastic and isotropic. The mechanical properties of the compact and cancellous bones and teeth in the model were defined according to the experimental data in previous studies[5-7] as shown in Table I. All sutures were assumed to have the same mechanical properties as the surrounding bone material except at the palatinal bone.

The two parts of the palatinal bone that are separated by the vertical plane of symmetry were assumed to be unconnected, so that they moved freely in lateral directions with respect to the vertical plane of symmetry. This was done to investigate the stress distribution and deformation of the craniofacial complex after splitting of the midpalatal suture.

All other points of the cranium lying on the symmetry plane were constrained to have no

Figure 4: Lateral view of the final 3-D finite element model constructed using Tet 10 solid elements

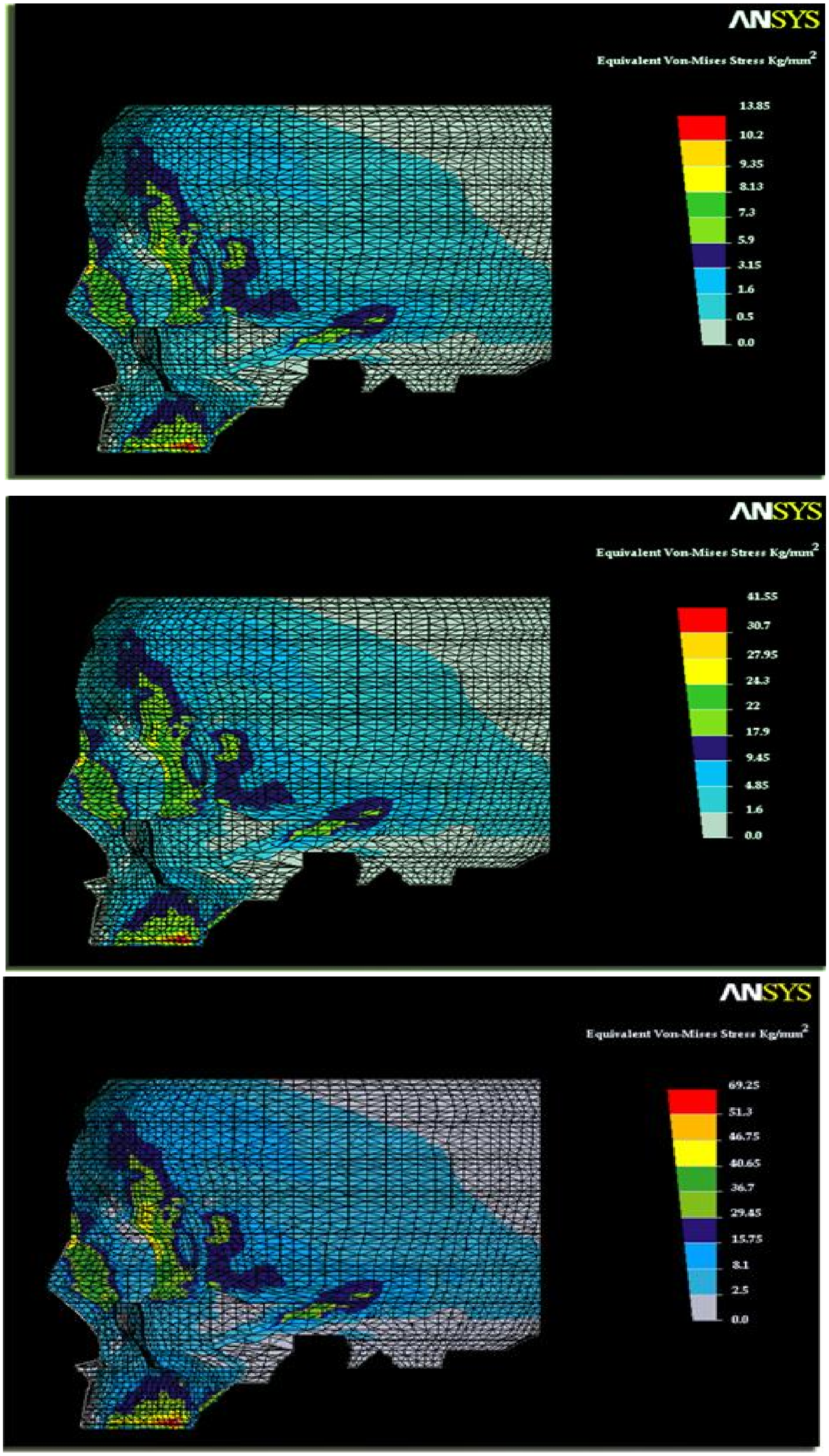


motion perpendicular to this plane. In addition, a zero-displacement and zero-rotation boundary condition was imposed on the nodes along the superior and posterior surface of the skull and along the foramen magnum.

Even though application of a known force is possible with FE modeling, known transversal (X) displacement with magnitudes of 1 mm, 3 mm and 5 mm were applied on the maxillary canine and first permanent molar crown. It was assumed that the two plates of transversal orthopedic appliance moved apart by a total of 2 mm, 6 mm and 10 mm respectively.

The displacements and Von-Mises stresses

Figure 5: Contour plots for stress distribution in craniofacial complex with (A) 1 mm, (B) 3 mm and (C) 5 mm of expansion



in different planes were studied on different nodes located at various structures of the craniofacial complex. The stress distribution patterns were analyzed; the results were tabulated and graphically represented.

Results

The biomechanical changes observed in this study were evaluated under the headings:

Table I: Material Properties

Material	Young's Modulus (kg/mm²)	Poisson's ratio
Tooth	2.07×10^3	0.3
Compact bone	1.37×10^3	0.3
Cancellous bone	7.90×10^2	0.3

Table II: Comparison of the computational result of transversal (X) displacement of the various structures of the craniofacial complex with varying amounts of expansion

Region	Selected nodes on	X (mm)		
		1 mm	3 mm	5 mm
Dentoalveolar	Incisal edge of 1	0.95	2.8	4.45
	Cusp tip of 3	0.82	2.4	4.28
	Cusp tip of 6	0.91	2.6	4.27
	Apical region of 1	0.71	1.41	3.78
	Apical region of 3	0.62	1.21	3.52
	Apical region of 6	0.69	1.51	3.67
Maxilla	Pt. "A"	0.2	1.4	3.9
	ANS	0.14	1.21	3.41
	Tuberosity	0.07	1.01	2.89
	Zyg. buttress	0.07	0.8	1.92
	Inf. orb. rim	0	0.31	0.82
	Frontal process	0	0.21	0.57
Palate	Anterior	0.27	1.34	3.54
	Posterior	0.02	0.94	1.84
Nasal cavity wall	Anteroinferior	0.51	1.06	3.24
	Anterosuperior	0.02	0.76	1.08
	Posteroinferior	0.01	0.8	1.7
	Posterosuperior	0	0.16	0.35
Nasal bone	Superior	0	0	0
	Inferior	0	0.03	0.15
Sphenoid bone	Medial pterygoid inferior	0	0.97	2.04
	Medial pterygoid superior	0	0.5	1.18
	Lateral pterygoid inferior	0	1.1	2.34
	Lateral pterygoid superior	0	0.11	0.32
	Greater wing	0	0.06	0.21
Zygomatic bone	Frontal process	0	0.23	1.62
	Zyg. arcus anterior	0	0.03	0.21
	Zyg. arcus posterior	0	0	0
	Body	0	0	0.07
Frontal bone	Supraorbital	0	0	0
	Forehead	0	0	0
Temporal	Squamous	0	0.02	0.15

Table III: Comparison of the computational result of sagittal (Y) displacement of the various structures of the craniofacial complex with varying amounts of expansion

Region	Selected nodes on	Y(mm)		
		1 mm	3 mm	5 mm
Dentoalveolar	Incisal edge of 1	0	0.11	0.35
	Cusp tip of 3	0	0.03	0.15
	Cusp tip of 6	0	0.24	0.74
	Apical region of 1	0	0.34	0.78
	Apical region of 3	0	0.21	0.5
	Apical region of 6	0	0.11	0.34
Maxilla	Pt. "A"	0	0.18	0.54
	ANS	0	0.21	0.72
	Tuberosity	0	0.02	0.12
	Zyg. buttress	0	0	0
	Inf. orb. rim	0	0	0.02
	Frontal process	0	0	0.02
Palate	Anterior	0.17	0.74	1.21
	Posterior	0.09	0.68	1.09
Nasal cavity wall	Anteroinferior	0	0.09	0.24
	Anterosuperior	0	0	0.12
	Posteroinferior	0.07	0.15	0.21
	Posterosuperior	0	0	0
Nasal bone	Superior	0	0	0
	Inferior	0	0	-0.12
Sphenoid bone	Medial pterygoid inferior	0	-0.2	-0.6
	Medial pterygoid superior	0	-0.07	-0.12
	Lateral pterygoid inferior	0	0.1	0.26
	Lateral pterygoid superior	0	0	0.1
	Greater wing	0	-0.06	-0.21
Zygomatic bone	Frontal process	0	-0.27	-0.71
	Zyg. arcus anterior	0	-0.34	-0.82
	Zyg. arcus posterior	0	-0.09	-0.32
	Body	0	-0.18	-0.27
Frontal bone	Supraorbital	0	0	0
	Forehead	0	0	0
Temporal	Squamous	0	0	0

1) Displacement of different bones of the craniofacial complex with varying amounts of transverse expansion.
2) Stress distribution observed at different bones of the craniofacial complex with varying amounts of transverse expansion.

Displacements of the craniofacial structures were studied in 3 dimensions: transversal –(X) plane, sagittal –(Y) plane and vertical –(Z) plane. Positive value (+) indicated an anterior movement in a sagittal (Y) plane and an upward movement in the vertical (Z) plane. Negative value (-) indicated a posterior movement in a sagittal (Y) plane and a downward movement in the vertical (Z) plane.

Displacement in the transverse plane: (X-displacement) (Table II)

Maximum X-displacement (lateral displacement) was 4.45 mm at node corresponding to the incisal edge of upper central incisor. Displacements were noted more in the dentoalveolar region compared to the skeletal changes.

Table IV: Comparison of the computational result of transversal (X), sagittal (Y), and vertical (Z) displacement of the various structures of the craniofacial complex with varying amounts of expansion

Region	Selected nodes on	Z(mm)		
		1 mm	3 mm	5 mm
Dentoalveolar	Incisal edge of 1	-0.12	-0.3	-0.65
	Cusp tip of 3	0	0.12	0.32
	Cusp tip of 6	0	0.08	0.26
	Apical region of 1	0	-0.2	-0.5
	Apical region of 3	0	0.09	0.21
	Apical region of 6	-0.02	-0.08	-0.14
Maxilla	Pt. "A"	-0.01	-0.45	-1.02
	ANS	0	-0.34	-0.98
	Tuberosity	0	0.09	0.17
	Zyg. buttress	0.07	0.17	0.36
	Inf. orb. rim	0	0.09	0.22
	Frontal process	0	0	0.07
Palate	Anterior	0	-0.3	-0.87
	Posterior	0	-0.24	-0.92
Nasal cavity wall	Anteroinferior	0	0	-0.24
	Anterosuperior	0	0	-0.03
	Posteroinferior	0	0	-0.14
	Posterosuperior	0	0	-0.03
Nasal bone	Superior	0	0	0
	Inferior	0	-0.09	-0.37
Sphenoid bone	Medial pterygoid inferior	0	-0.31	-0.82
	Medial pterygoid superior	0	0	0.9
	Lateral pterygoid inferior	0	-0.31	-0.87
	Lateral pterygoid superior	0	0.14	0.1
	Greater wing	0	0.08	0.24
Zygomatic bone	Frontal process	0	0.34	0.98
	Zyg. arcus anterior	0	0.11	0.34
	Zyg. arcus posterior	0	0	0.02
	Body	0.12	0.28	0.7
Frontal bone	Supraorbital	0	0	0
	Forehead	0	0	0
Temporal	Squamous	0	0	0

With 1 mm of separation of expansion device on each side, changes were evident only in the dentoalveolar region and anterior maxillary region. As the expansion device was further separated, displacements of the adjacent structures were noticeable.

Expansion was more in anterior maxillary area compared to the posterior. From the frontal view, pyramidal displacement of maxilla away from the midline was evident.

The width of the nasal cavity at the floor of the nose increased markedly where as the posterosuperior part of the nasal cavity had moved minimally in the lateral direction. No significant lateral displacement was observed at the temporal, frontal and sphenoid bone. The inferior parts of the pterygoid plates, however, demonstrated lateral displacement or bending. But minimum displacement was observed in the region close to the cranial base, where the plates were more rigid.

Displacement in the anteroposterior plane: (Y - displacement) (Table III)

Table V: Comparison of maximum Von-Mises stresses on the various structures of the craniofacial complex with varying amounts of transverse expansion

Region	Selected nodes on	Max. Von-Mises stress (Kg/mm^2)		
		1 mm	3 mm	5 mm
Dentoalveolar	Incisal edge of 1	0.22	0.45	0.81
	Cusp tip of 3	0.9	2.1	2.7
	Cusp tip of 6	1.4	2	3.4
	Apical region of 1	0.94	1.72	3.21
	Apical region of 3	12.41	18.06	22.32
	Apical region of 6	12.57	16.07	20.71
Maxilla	Pt. "A"	0.8	1.8	2.6
	ANS	0.8	1.64	2.14
	Tuberosity	0.92	1.72	3.24
	Zyg. buttress	2.5	4.72	6.04
	Inf. orb. rim	0.62	1.24	2.02
	Frontal process	0.57	1.12	2.12
Palate	Anterior	0.49	0.92	1.21
	Posterior	0.8	1.27	3.24
Nasal cavity wall	Anteroinferior	5.24	13.84	20.42
	Anterosuperior	1.02	3.41	4.98
	Posteroinferior	1.82	4.27	6.28
	Posterosuperior	0.71	1.37	2.02
Nasal bone	Superior	2.4	7.34	12.14
	Inferior	4.1	10.21	15.28
Sphenoid bone	Medial pterygoid inferior	2.1	8.94	14.24
	Medial pterygoid superior	7.24	57.24	74.24
	Lateral pterygoid inferior	1.84	7.53	12.24
	Lateral pterygoid superior	8.24	55.14	68.17
	Greater wing	3.24	34.27	51.24
Zygomatic bone	Frontal process	3.17	14.04	22.04
	Zyg. arcus anterior	1.61	3.54	7.24
	Zyg. arcus posterior	0.8	1.84	2.14
	Body	1.41	3.71	5.24
Frontal bone	Supraorbital	0.9	1.37	2.8
	Forehead	0.27	0.83	1.02
Temporal	Squamous	0	0.01	0.02

Maximum positive Y-displacement (forward displacement) was 1.21 mm at node representing the anterior aspect of palate followed by 1.09 mm at posterior aspect. All the dentoalveolar structures, maxillary structures, and structures on nasal cavity wall demonstrated forward displacement to varying extent. These changes were evident when the expansion was beyond 3 mm on each side.

Maximum negative Y-displacement (backward displacement) of 0.82 mm was noted at the node representing the anterior region of zygomatic arc. Overall, the zygomatic bone displayed a backward displacement.

Displacement in the vertical plane: (Z - displacement) (Table IV)

Maximum positive Z-displacement (upward displacement) was 0.98 mm at node representing the frontal process of the zygomatic bone. Maximum negative Z-displacement (downward displacement) was

Region	Selected nodes on	X (mm)			Y (mm)			Z (mm)		
		Iseri et al	Jafari *et al*	Present study	Iseri *et al*	Jafari *et al*	Present study	Iseri *et al*	Jafari *et al*	Present study
Dentoalveolar	Incisal edge of 1	5	5.31	4.45	1.4	0.85	0.35	-1.4	-0.45	-0.65
	Cusp tip of 6	5	5.31	4.27	1.4	0.74	0.15	-0.8	0.26	0.26
	Apical region of 1	4.99	4.34	3.78	2.1	0.85	0.74	-1.2	-0.59	-0.5
	Apical region of 3	4.99	3.94	3.52	2.1	0.5	0.5	-1.1	0.26	0.21
	Apical region of 6	4.91	4.08	3.67	2	0.49	0.34	-0.4	0.29	-0.14
Maxilla	Anterior part of palate	4.9	3.22	3.54	2.1	1.03	1.21	-1.1	-0.61	-0.87
	Posterior part of palate	4.8	2.06	1.84	2.1	1.05	1.09	-0.2	-1.02	-0.92
Sphenoid bone	Lateral pterygoid inferior	4.9	2.07	2.34	1.8	0.59	0.26	-0.04	-0.44	-0.87
	Lateral pterygoid superior	1.4	0.44	0.32	1.6	0.08	0.1	-0.7	0.13	0.1
Zygomatic bone	Frontal process	3.9	2.07	1.62	1.6	-0.98	-0.71	-0.4	1.42	0.98
	Zyg. arcus anterior	3.3	0.44	0.21	0.7	-0.93	-0.82	0.4	1.67	0.34
	Zyg. arcus posterior	0.6	0.04	0	-0.04	-0.38	-0.32	0.2	0.06	0.02
Nasal cavity wall	Anteroinferior	4.8	3.25	3.24	2.1	0.52	0.24	-1.1	0	-0.24
	Anterosuperior	4.8	1.26	1.08	2.1	0.16	0.12	-0.02	-0.02	-0.03
	Posterosuperior	-0.3	0.65	0.35	0.2	0.02	0	-1.1	-0.02	-0.03
Nasal bone	Body	0.3	0.23	0.15	-1.2	-0.5	-0.12	-1.1	-0.59	-0.37
Frontal bone	Supraorbital	0.03	0.01	0	-0.2	-0.02	0	-0.5	0.1	0
Temporal	Squamous	0.1	0.6	0.15	0.08	-0.25	0	0.4	0.59	0

1.02 mm of point 'A', indicating a downward displacement of maxilla. Considering both these points, it is evident that the nasomaxillary complex rotated in such a manner that the lateral structures had moved upward and midline structures downward. The anterior part of the maxillary bone (point A and ANS) and maxillary central incisors were displaced downward.

Comparison of maximum Von-Mises stresses on various structures of the craniofacial complex with varying amounts of expansion

Table V shows the comparison of maximum Von-Mises stresses on the various craniofacial structures with varying amounts of expansion. The findings show that the stresses at the nodes varied linearly for the given displacement boundary conditions due to RME.

Initial stress images of the three-dimensional model of skull are as shown in Fig 5 A, B and C. The areas of stress are shown with the help of different colours. The pellets of colours representing the tensile and compressive stresses are shown on the right-hand side of the diagram. Using the computer-generated colour diagrams the following results were obtained.

In the dentoalveolar region, the stresses were high in apical region of canine and first molar and they continued to increase as the expansion progressed. In the maxilla, zygomatic buttress demonstrated high stress values compared to the other areas evaluated. The posterior region of the palate demonstrated higher stress values compared to the anterior region. The anteroinferior region of the nasal cavity demonstrated stresses in range of 5.24 - 20.42 kg/mm^2, which were highest for the areas assessed.

Highest stress levels were observed in the pterygoid plates of sphenoid bone. The findings indicated that high stresses produced by RME are especially located in the superior parts of the pterygoid processes of the sphenoid bone (74.24 kg/mm^2 at medial and 68.17 kg/mm^2 at lateral pterygoid). The greater wing of sphenoid also demonstrated high stress levels (51.24 kg/mm^2).

Discussion

Finite element analysis is a mathematical method in which the shape of complex geometric objects and their physical properties are computer constructed. Interactions of various components of the model are then calculated for stress, strain and deformation. This method was first used in orthodontics by Thresher and Saito (1973)[8] to study stresses in human teeth. Ever since, this method has proved effective in many dental fields such as simulation of tooth movement and optimization of orthodontic mechanics. Such an extensive use has been primarily done because of its advantages. The method is non-invasive; the actual amount of stress experienced at any given point can be theoretically measured; the tooth, alveolar bone, periodontal ligament, and craniofacial bones can be simulated; the displacement of the tooth and the craniofacial complex can be visualized graphically; the point of application, magnitude, and direction of a force may easily be varied to simulate the clinical situation, reproducibility does not affect the physical properties of the involved material; and the study can be repeated as many times as the operator wishes.

The 3-dimensional FEM used in the present study provided the freedom to simulate orthodontic force systems applied clinically and allowed analysis of response of the craniofacial skeleton to the orthodontic loads in three-dimensional space.

The experimental method employed in this study permitted the visualization of bone reactions, even with the lowest loading degree. One should be aware that the structural and spatial relationships of various craniofacial components vary among individuals. It is important to realize that these factors may contribute to the varied responses of the craniofacial components on loading in vivo. Thus, the results of this study are valid only for a single specific human skull.

This can be seen as a problem in generalizing the findings obtained in this study. On the other hand, studies done by Iseri *et al*[7] and Jafari *et al*[6] yielded same results in spite of the differences in method used and the variation in skull geometry. Iseri *et al*[7] used CT images of a 12-year old patient while Jafari *et al*[6] constructed the model from CT images of dry human skull with an approximate age of 12 years. They showed that, although there were differences in the craniofacial structures between subjects, the responses to the same mechanical forces were same in the FEM.

So, though there were quantitative differences (Table VI), qualitatively, the mechanical response was predicted in the same manner, which is a positive indication for the validity of the qualitative conclusions.

Though we used an adult human skull to develop the finite element model, the displacements of the various craniofacial structures were compared with similar corresponding structures of the previous studies.[6,7]

Overall pattern of displacement

The pattern of displacement revealed that the greatest widening was observed in the dento-alveolar structures, with the expansion effect gradually decreasing towards the superior structures. The results of the present study support those of the previous studies[6,7], which reported the maxillary suture to separate supero-inferiorly in a non-parallel manner, the separation being pyramidal in shape with base of the pyramid located at the oral side of the bone and the centre of rotation located near the frontonasal suture.

In the sagittal (Y) plane, the structures along the midline showed an anterior displacement while the lateral structures demonstrated a posterior displacement.

In the vertical (Z) plane, the entire maxillary complex descended downwards more or less in a parallel manner while the lateral structures demonstrated an upward displacement.

Overall pattern of stress distribution

Stresses produced by the expansion appliance were concentrated in the anterior region of the palate. The initial effects of the expansion were observed at region of central incisors.

With increased activations, stresses radiated from the midpalatine area superiorly along the perpendicular plates of the palatine bone to deeper anatomic structures. The buttressing of the maxillary tuberosity with the pterygoid plates of the sphenoid bone allowed the forces to then radiate to the base of the medial pterygoid plate.

From this region, the stresses then spread further superiorly toward the malar and the zygomatic bones.

Heavy stresses were observed in the area of the base of pterygoid plates of sphenoid bone. *These areas of stress concentration indicate regions of potential weakness or regions where major biologic responses may be expected*.

If the maxilla is fused to the pterygoid plates, as is the probable case in adult patients, intermaxillary expansion would be difficult to obtain, regardless of how much the suture between the two halves of maxilla are affected by the orthopedic forces.

Unlike the maxillae, the pterygoid processes are not individual bones, but parts of the same cranial bone - the sphenoid. So, even if surgically assisted rapid maxillary expansion (SA-RME) is advocated, the osteotomized maxillae and palatine bones would move apart on application of expansion forces, but the fused pterygoid processes which cannot separate, tend to splay outward.

In children and adolescents, the midpalatal and circummaxillary sutures generate less resistance to expansion forces, thus limiting the development of internal stresses in the dentoalveolar region. Consequently, maxillary expansion is accompanied by sutural adjustments in the craniofacial complex in remote regions, rather than by alveolar remodeling or tipping. However, these adaptive changes cannot be exploited following skeletal maturation because the sutures are no longer patent and the expansion forces are now resisted by the reinforcing buttresses of the midfacial skeleton. The heavy stresses at the pterygoid plates can radiate across to deeper anatomic structures, including the body and greater wings of sphenoid bone thereby denoting far-reaching effects of orthopedic expansion of maxilla in adults.

Contrary to conventional perception, this study along with the previous studies[6,7,9,10] disclosed that resistance provided by the pterygomaxillary articulations was greater than that of the zygomaticomaxillary buttresses.

The results of the present study using the three-dimensional FEM of an Adult Human Skull provided explanation about the mechanical reactions of the bony tissues, which are the first steps in the complex and dynamic process of tissue response to maxillary expansion.

However, as stated previously, FE method has certain limitations, most important being the results applicable only to the FE model created. It may not necessarily apply to all individuals quantitatively. However, what is important is that most of them, would give QUALITATIVELY THE SAME RESULTS as were obtained in the present study, which can prove useful if employed judiciously.

The present study is precisely for the purpose of highlighting the qualitative differences in biomechanical effects of RME employed in an adult. Simulation models that are being used for diagnostic, operational planning or rehearsal purposes in the field of medical sciences can be effectively and efficiently employed in the field of orthodontics and maxillofacial surgery.

Conclusion

It can be thus concluded from the present study that:

- Finite element analysis is a valid, reliable and fairly accurate method of analysis of stresses generated in the craniofacial complex.

- Accurate geometric model of craniofacial skeleton should be created to study the displacement and stresses in the craniofacial complex and skeleton.
- Though expansion can be achieved in adults, displacements are noted more in the structures located anteriorly and along the midline while the posterior and lateral structures demonstrate minimal displacement but high stresses.
- Rapid maxillary expansion must be used judiciously in adults, because of its far-reaching effects involving heavy stresses being noted at the sphenoid bone, zygomatic bone, nasal bone and their adjacent sutures.
- Specific responses in individual cases, especially in adults, can be predetermined with the use of simulation models and the design of treatment mechanics, accordingly tailored.

It is hoped that this further exploration of the skeletal and dental effects of transverse orthopedic forces better defines the parameters of clinical expectations from this orthopedic procedure when employed in adults.

References

1. Cameron CG, Franchi L, Baccetti T, McNamara JA. Long–term effects of rapid maxillary expansion. A posteroanterior cephalometric evaluation. *Am J Orthod Dentofac Orthop*. 2002; 121: 129-35.
2. Bishara SE, Staley RN. Maxillary expansion: clinical implications. *Am J Orthod Dentofac Orthop*. 1987; 91: 3-14.
3. Proffit WR, Fields HW, Ackerman JL, Bailey LT, Tulloch JFC. Contemporary Orthodontics. 3rd Ed. St. Louis: Mosby Inc; 2000.
4. McNamara JA Jr, Brudon WL. Orthodontic and orthopedic treatment in the mixed dentition. Ann Arbor, Mich: Needham Press; 1993.
5. Tanne K, Harage J, Kakiuchi K, Uamagat Y, Sakuda M. Biomechanical effect of anteriorly directed extraoral forces on the craniofacial complex: A study using the finite element method. *Am J Orthod Dentofac Orthop*. 1989; 95: 200-7.
6. Jafari A, Shetty KS, Kumar M. Study of stress distribution and displacement of various craniofacial structures following application of transverse orthopedic forces. A three-dimensional FEM study. *Angle Orthod*. 2003; 73: 12-20.
7. Iseri H, Tekkaya AE, Oztano, Bilgic S. Biomechanical effects of rapid maxillary expansion on the craniofacial skeleton, studied by the finite element method. *Eur J Orthod.* 1998; 20: 347-56.
8. Thresher RW, Saito GE. The stress analysis of human teeth. *J Biomech*. 1973; 6: 443-9. Cited in Tanne K, Sakuda M, Burstone CJ. Three-dimensional finite element analysis for stress in the periodontal tissue by orthodontic forces. *Am J Orthod Dentofac Orthop*. 1987; 92: 499-505.
9. Chaconas SJ, Caputo AA. Observation of orthopedic force distribution produced by maxillary orthodontic appliances. *Am J Orthod*. 1982; 82: 492-501.
10. Shetty V, Mendoca Caridad J, Caputo AA, Chaconas SJ. Biomechanical rationale for surgical-orthodontic expansion of the adult maxilla. *J Oral Maxillofac Surg*. 1994; 52: 742-749.

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Determination of Sex from Index and Ring Finger Ratio

Dahodwala Taikhoom Mohammed*, Bardale Rajesh, Sonar Vaibhav*****

Abstract

Background: Establishment of sex has considerable forensic implication. Earlier studies have shown that differences exist between male and female index and ring finger ratios. **Aim**: The purpose of present study is to evaluate sexual dimorphism of index and ring finger in western part of the Indian population. **Material and Method**: The study was carried out on a cross sectional sample of 195 adult students out of which 100 of the respondents were males and the remaining 95 were females. Data on age, sex, height and weight were collected through structured paper questionnaire as primary data collection and the anthropometric measurements as secondary data collection. **Result**: The result of present study shows that the mean age of male population is 21.52 years while the mean age of female population is 20.08 years. Statistically significant difference ($p < 0.05$) between index and ring finger ratios in male and female are observed. **Conclusion:** The present study suggests that the ratio of less than 0.97 suggests male sex while a ratio of 0.97 or more suggests female sex. The findings of present study can be utilized to establish sex especially in circumstances where body was mutilated or only remains were brought or in cases of mass disaster

Keywords: Identification; Sex difference; Index finger, Ring finger, Anthropometry.

Introduction

Establishment of sex has considerable forensic implication. It assumes greater importance when the bodies are mutilated or only remains are brought for medical examination. Previous studies have shown that hand exhibits sexual dimorphism and the dimensions can be utilized to establish sex of a person.[1-3] Earlier studies have shown that differences exist between male and female index (2D) and ring finger (4D) ratios (2D:4D).[4-10] It was observed that digit ratios vary according to the ethnicity and population groups.[11,12] Ethnic differences in digit ratio could result from ethnic differences in prenatal androgenization, but this has not been empirically tested.

In India, index and ring finger ratio had been studied in South Indian population and it was noted that the ratio can be a useful sex indicator to differentiate between male and female.[13-15] However, such studies are not available for the other part of country and therefore the purpose of present study is to evaluate sexual dimorphism of index and ring finger in western part of the Indian population.

Material and Method

Sample size and sampling techniques

The present prospective study consists of adult students of Government Medical College, Miraj, District Sangli, Maharashtra who were randomly selected from the 5 year batches. The study was carried out on a cross sectional sample of 195 adult students out of which 100 of the respondents were males and

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the remaining 95 were females. Data on age, sex, height and weight were collected through structured paper questionnaire as primary data collection and the anthropometric measurements as secondary data collection. The length of the second digits (2D) and fourth digits (4D) of the left and right hand of each subject were measured with the aid of manual vernier calipers, from the tip of the digit to the ventral proximal crease, where there was a band of crease at the base of the digit, the most proximal crease was used. Subjects with injuries or deformities in any of the hands were excluded from the study. All measurements were made in centimeters to the nearest millimeter with digits fully extended.

Instrumental design

The instrument used for the study was a structured questionnaire titled ''determination of sex on the basis of measurement of the index and the ring finger''. The questionnaires consist of personal demographic information with questions on the age, weight, height and handedness of the volunteer, while part two contained information on anthropometric measurements.

Method of validation of instrument

Three parameters were investigated which includes height, weight and the length of index (2D) and ring (4D) of both hands. Careful and appropriate steps were taken to protect the rights of the respondents. Potential respondents were informed that the survey was completely voluntary and all participation was confidential.

Statistical analysis

Data was expressed as mean ± Standard deviation (± SD). Descriptive statistics and Students'-test were used to analyze and determine the parameters studied in both males and females. 2D:4D ratio was calculated on both hands of each individual. The relationship between the parameters studied was established using Pearson correlation to establish the strength of the relationship between the lengths of second and fourth digits (2D&4D), the digit ratios and the other anthropometric variables in both sexes. Statistical significance was accepted at P value less than or equal to <0.05 ($P<0.05$). The sectioning point was calculated for sex differentiation from the index and ring finger ratios as – mean male ratio + mean female ratio ÷ 2.

Result

The result of present study shows that the mean age of male population is 21.52 years while the mean age of female population is 20.08 years. The mean height of (171.6 cm) men exceeds the mean height (157.3 cm) of women. Similarly the mean BMI of men (22.48) exceeds that of mean BMI (21.48) of women (Table1). It is observed that the index and ring finger shows significant difference between the lengths in both sexes ($P < 0.05$). The mean lengths of index and ring finger in male are 7.35 cm and 7.66 cm respectively in right hand and 7.34 cm and 7.67 cm in left hand respectively. The mean lengths of index and ring finger in female are 6.80cm and 6.93

Table 1: Showing age and sex related descriptive data

Parameters	Male (n = 100)				Female (n = 95)			
	Min	Max	Mean	SD	Min	Max	Mean	SD
Age	19	26	21.52	1.41	18	23	20.81	0.97
Weight (in KG)	50	98	66.05	9.44	34	77	53.13	5.26
Height (in cm)	158	190	171.46	7.08	145	172	157.3	8.01
BMI	22.62	30.47	22.48	3.01	14.79	30.91	21.48	3.21

Table 2: Showing the descriptive statistics of male and female index and ring finger measurements (in cm)

Sex	Parameters	Min	Max	Mean	SEM	SD	Significance
Male (n = 100)	R2D	6.36	8.37	7.35	0.041	0.414	P < 0.05
	R4D	6.76	8.78	7.66	0.046	0.462	
	L2D	6.40	8.30	7.34	0.042	0.423	P < 0.05
	L4D	6.74	8.89	7.67	0.046	0.467	
Female (n = 95)	R2D	5.99	7.78	6.80	0.036	0.357	P < 0.05
	R4D	6.11	7.84	6.93	0.036	0.357	
	L2D	5.98	7.53	6.76	0.034	0.334	P < 0.05
	L4D	6.11	7.63	6.92	0.037	0.365	

Table 3: Showing the difference between male and female index and ring fingers (in cm)

Parameters	Male	Female
	Mean ± SD	Mean ± SD
R2D – R4D	0.28 ± 0.23	0.13 ± 0.15
L2D – L4D	0.33 ± 0.20	0.16 ± 0.18

cm respectively in right hand and 6.76 cm and 6.92 cm in left hand respectively (Table 2). However, no significant difference exists between the lengths of index and ring finger in right and left hand in both sexes (Table 2). In male, the mean difference between index and ring finger in right hand is 0.28 ± 0.23 cm and in left hand it is 0.33 ± 0.20 cm. In female, the mean difference between index and ring finger in right hand is 0.13 ± 0.15cm and in left hand it is 0.16 ± 0.18 cm (Table 3). Statistically significant difference ($p < 0.05$) between 2D:4D ratios in male and female are observed (Table 4). In male, the mean 2D:4D ratio in right and left hand is 0.960 and 0.957 respectively while in female the mean 2D:4D ratio in right and left hand is 0.981and 0.978 respectively (Fig 1 and 2).

A sectioning point was calculated for the index and ring finger ratios (2D:4D) to differentiate between male and females and the value is 0.97. A ratio of 0.97 or more is suggestive of female while ratio less than 0.97 suggest male sex. With this sectioning point we could predict 69% males from right hand and 77% males from left hand. Similarly with a value of 0.97 or more we could predict 62.5% females from right hand and 59.85% females from left hand.

Discussion

In human hand the second and fourth digit presents a pattern of approximate symmetry around the central axis of third digit. However, there is considerable variation in the ratio of length of second digit to fourth digit. The ratio between the length of the index and ring finger (2D:4D) is sexually dimorphic with males having on an average longer fourth finger (ring finger) relative to their second finger (index finger) showing a low 2D:4D ratio than females, who had on an average have a higher 2D:4D ratio.[4,7] This sexual dimorphism in 2D: 4D ratio is apparent by 2 years of age and appear to be established early in life, by the 14th week of gestation [5,6,9]. The differences may be linked to the prenatal production of testosterone and oestradiol and, in the case of testosterone, to interactions with the homeobox genes *Hoxa* and *Hoxd*, which control differentiation of the urogenital system and development of the digits [10].

Table 4: Showing the ratios of index and ring fingers in male and female subjects

Sex	Parameters	Min	Max	Mean	Median	SD	CV*%	CD**	Correlation
Male (n = 100)	D2:D4 ratio right	0.899	1.044	0.960	0.960	0.027	2.8%	0.021	0.892
	D2:D4 ratio left	0.894	1.038	0.957	0.957	0.025	2.6%	0.020	0.903
Female (n = 95)	D2:D4 ratio right	0.935	1.031	0.981	0.982	0.022	2.2%	0.018	0.909
	D2:D4 ratio left	0.889	1.050	0.978	0.980	0.027	2.7%	0.021	0.860

*CV% = coefficient of variation, **CD = coefficient of dispersion

Fig 1: Showing index to ring finger ratio in both hands in male population

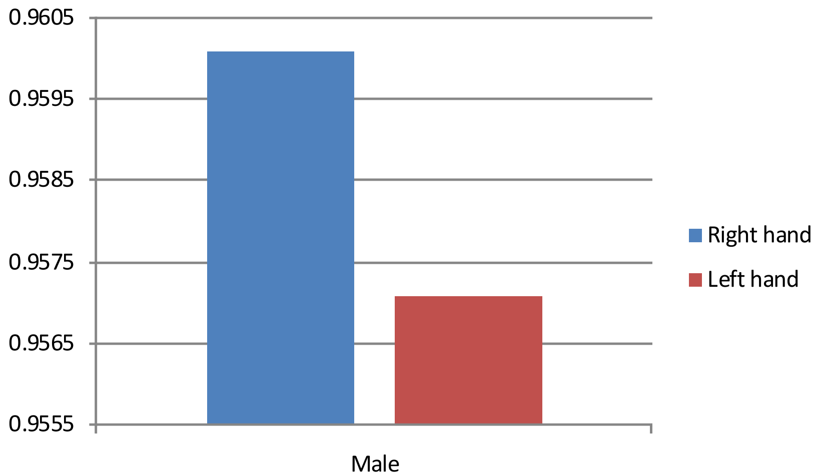
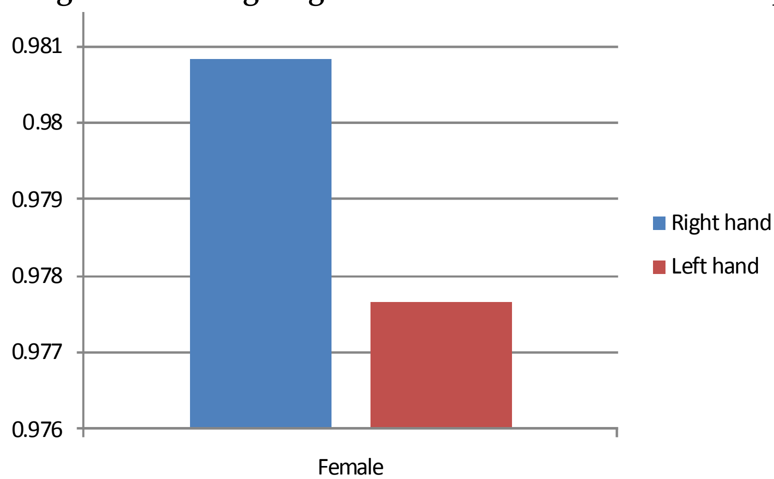


Fig 2: Showing index to ring finger ratio in both hands in female population



The sex difference in 2D:4D ratio is present before birth in human and therefore it rules out any social influences that might affect digit growth. However, ethnicity differences in 2D:4D are apparent in first 2 years of life.[7,9,12] A low 2D:4D ratio has been shown to correlate with high testosterone levels which are characteristic of males, while a high 2D:4D ratio is correlated with low testosterone level, a characteristic of females.[4]

Manning *et al* (2000) had noted that females had longer second digits than fourth digits while males have longer fourth digits than second digits. This difference was accounted for higher digit ratios in females than in males. It was observed in present study that second finger length of Indian males was shorter than fourth finger and statistically significant difference was noted ($P < 0.05$). The findings are in accordance with other studies.[4,6,7,13,14,15] Similarly in females we observed that the lengths of second and fourth digits were approximately same or was like that of males. We had also noted that males have longer digits compared to females. The 2D:4D ratio has been found to be sexually dimorphic with females having higher digit ratios (≥ 0.97) compared to males. The findings are in accordance with earlier published literature.[13-15]

In conclusion we have noted that males have longer digits than females. It was observed that lengths of second and fourth digits in females were approximately same or was like that of males. The 2D:4D ratios were found higher in females than males and appear sexually dimorphic. The present study suggests that 2D:4D ratio of less than 0.97 suggests male sex while a ratio of 0.97 or more suggests female sex. The findings of present study can be utilized to establish sex especially in circumstances where body was mutilated or only remains were brought or in cases of mass disaster.

References

1. Kanchan T, Rastogi P. Sex determination from hand dimensions of North and South Indians. *J Forensic Sci*. 2009; 54: 546-50.
2. Krishan K, Kanchan T, Sharma A. Sex determination from hand and foot dimensions in a North Indian population. *J Forensic Sci*. 2011;56:453-9
3. Jowaheer V, Agnihotri AK. Sex identification on the basis of hand and foot measurements in Indo-Mauritian population – a model based approach. *J Forensic Leg Med.* 2011; 18:173-6
4. Ibegbu AO, Danjuma ZC, Hamman WO, Umana UE, Ikyembe DT, Musa SA. Anthropometric study of the index (2nd) and ring (4th) digits in Ebira ethnic group of Nigeria. *Asian J Med Sci*. 2012; 4: 79-84.
5. Galis F, Broek TCMA, Van Dongen S, Wijnaendts LCD. Sexual Dimorphism in the prenatal digit ratio (2D:4D). *Arch Sex Behav.* 2010; 39: 57–62.
6. Manning JT, Scutt D, Wilson J, Lewis-Jones DI. The ratio of 2nd to 4th digit length: A predictor of sperm numbers and concentrations of testosterone, luteinizing hormone and oestrogen. *Hum Reprod.* 1998; 13: 3000-04.
7. Manning JT, Barley L, Walton J. The 2nd:4th digit ratio, sexual dimorphism, population differences and reproductive success: Evidence for sexually antagonistic genes? *Evol Hum Behav.* 2000; 21: 163-83.
8. McFadden D, Loehlin JC, Breedlove SM, Lippa RA, Manning JT, Rahman Q. A reanalysis of five studies on sexual orientation and the relative length of the 2nd and 4th fingers (the 2D:4Dratio). *Arch Sex Behav.* 2005; 34: 341-56.
9. Malas MA, Dogan S, Evcil EH, Desdicioglu K. Fetal development of the hand, digits and digits ratio (2D:4D). *Early Hum Dev.* 2006; 82: 469-75.
10. Gillam L, McDonald R, Ebling FJP and Mayhew TM. Human 2D (index) and 4D (ring) finger lengths and ratios: cross-sectional data on linear growth patterns, sexual dimorphism and lateral asymmetry from 4 to 60 years of age. *J Anat.* 2008; 213: 325-35.
11. Manning JT, Stewart A, Bundred PE, Trivers RL. Sex and ethnic differences in 2nd to 4th digit ratio of children. *Early Hum Dev.* 2004; 80: 161-168.
12. Churchill ATG, Manning JT, Peters M. The effect of the sex, ethnicity and sexual orientation on self-measured digit ratio (2D:4D). *Arch Sex Behav*. 2007; 36: 251-60.
13. Kanchan T, Kumar GP, Menezes RG. Index and ring finger ratio – a new sex determinant in south Indian population. *Forensic Sci Int.* 2008; 181: 53e1-e4.
14. Kanchan T, Kumar GP, Menezes RG, Rastogi P, Rao PP, Menon A *et al*. Sexual dimorphism of the index to ring finger ratio in South Indian adolescents. *J Forensic Leg Med*. 2010; 17: 243-6.
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[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.

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[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.

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[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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