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CONTENTS

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A Pilot Study to find out Sexual Dimorphism in Human Skulls using Curvilinear Sagittal Suture Length

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ABSTRACT

Introduction: Identification is the determination of the individuality of a person based on certain physical characteristics, i.e., exact fixation of personality. Correct sex estimation reduces the possible number of individuals that need to be considered by approximately 50%. According to Krogman, sexing can be 90% accurate by skull alone, but till dateonly a handful of studies have been undertaken to study the relation of cranial suture length with parameters like sex and stature.

Material and Method: This study was conducted on 400 deceased adults brought for post-mortem examination during study period. All the observations related to the current study were done by naked eye and data regarding age, sex and curvilinear length of sagittal suture were recorded.

Results: The mean curvilinear length of sagittal suture was 12.42 ± 0.74 cm in females and 12.76 ± 0.71 cm in male and the mean length of the sagittal suture was significantly higher among males as compared to females.

Conclusion: Curvilinear length of sagittal suture is a reliable predictor of sex.

Keywords: Curvilinear length; Sagittal suture; Sexual dimorphism; Identification.

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INTRODUCTION

Identification is the determination of the individuality of a person based on certain physical characteristics, i.e., exact fixation of personality.[1] Exact identification is particularly important, and at the same time equally difficult, when there is evidence of effacement of identity or when identifying an unknown person; in cases of man-made mass disasters and natural calamities. Also, with increasing tendency of crime perpetrators towards destroying the identity of the victim, either by acts of commission like dismembering, decapitation, post-mortem burning, dumping in water body, etc. or by intentional neglect by leaving the dead body on terrains like forests, open grounds, farmlands wherein the natural elements like sunlight, rain, wind and scavenging animals act upon the dead; we end up with partly or wholly skeletonized remains of the deceased reaching us from the scene of recovery to our autopsy rooms.[2] Sex, age and stature are primary characteristics of identification.[1]

Correct sex estimation is critically important during identification as it reduces the possible number of individuals that need to be considered by approximately 50%. Therefore, sexing is of greater value than age, stature, and race identification.[3] Generally, DNA analysis for sexing of bones is the most accurate method. However, the high cost along with sophisticated extraction and analysis techniques critically limit its utility. Also, forensic DNA extraction from bone raises several issues, because the samples are very often badly altered and/or in very small quantity.[4,5] Therefore, we have to rely on anthropometric techniques to provide more convenient methods in sex estimation.

In order to predict sex of an individual, metric methods are considered to perform better than morphological methods, as the former eliminates the subjectivity inherent to morphological assessment and thus reduces the inter-observer and intra-observer errors.[6,7] Though metric methods have reasonable accuracy rates, it is evident that one population standard should not be used for another population for sex assessment as there may be a significant variability in sexual dimorphism between populations.[8]

Till date, only a handful of studies have been undertaken to study the relation of cranial suture lengths with parameters like sex and stature. In the current study, we attempt to find whether curvilinear length of sagittal suture has any sexual dimorphismand can it be usedas a reliable indicator of sex.

MATERIAL AND METHOD

This analytical study with cross-sectional design was conducted on 400 deceased adults brought for post-mortem examination at the Department of Forensic Medicine of B.J. Govt. Medical College and Sassoon General Hospitals, Pune during April 2021 to May 2022, after obtaining clearance from institutional ethics committee. Deceased individuals of Indian origin, of more than 20 years of age, whose exact age at the time of death was known and confirmed by documentary evidence were included in the study. While known cases of non-Indian origin, unknown deceased individuals where exact age could not be confirmed, known cases of metabolic bone diseases, craniosynostosis, nutritional deficiency, skeletal malformation or deformity, endocrinal disorders, cancers and cases of fresh and healed skull fractures were excluded from the study.

All observations related to current study were done by naked eye at the time of medico-legal post-mortem examination of deceased. Data regarding age, sex and curvilinear length of sagittal suture were recorded. During post-mortem examination, after standard reflection of scalp, soft tissue over the skull vault was removed thoroughly to expose the sagittal suture from the bregma (anterior junction of sagittal and coronal sutures) up-to the lambda (posterior junction of coronal and lambdoid sutures). Curvilinear length of sagittal suture (i.e. distance between lambda and bregma) was measured with the help of a non-stretchable thread and a graduated scale.

RESULTS

Out of the 400 individuals included in the study, 317 (79.2%) were males while 83 (20.75%) were females. Thus, the sample showed male preponderance (Table 1).

Table 1: Sex-wise distribution of cases

Sex	Frequency (n)	Percent (%)
Female	83	20.75
Male	317	79.25
Total (N)	400	100.0

For the 83 female crania examined, the minimum and maximum ages were 20 years and 99 years respectively with mean age being 48.69 ± 21.67 years. For the 317 male crania examined, the minimum and maximum ages were 20 years and 85 years respectively with mean age 46.06 ± 15.78 years. On applying Mann-Whitney U test (p-value= 0.001, significant), we found that the mean age of females in study population is significantly higher as compared to males (Table 2).

All individuals were grouped as per their ages in a range of 10 years as shown in Table 3.

Table 2: Sex-wise mean age

Sex	Mean age (in years)	Minimum age (in years)	Maximum age (in years)	Std. dev.	P value (as per Mann Whitney U Test)
Female (n= 83)	48.69	20	99	21.67	0.001
Male (n= 317)	46.06	20	85	15.78	(Significant - S)

Table 3: Sex-wise and age group-wise distribution of cases

Age group (in years)	Females		Males		Total		P value (as per Chi square test)
	No.	Sex-wise percentage distribution within age group	No.	Sex-wise percentage distribution within age group	Total cases within age group (N=400)	Percentage distribution of total cases within age group	
20-29	25	34.25	48	65.75	73	18.25	0.1 (Not Significant -NS)
30-39	11	13.58	70	86.42	81	20.25	
40-49	7	9.59	66	90.41	73	18.25	
50-59	11	14.1	67	85.9	78	19.5	
60-69	10	21.74	36	78.26	46	11.5	
70-79	11	34.38	21	65.63	32	8	
80-89	6	40	9	60	15	3.75	
90-99	2	100	0	0	2	0.5	
Total	83	20.75	317	79.25	400	100	

The values from the table show that there was no significant difference between the females and males with regards to age range in our study population.

The values from the tables 4 and 5 show that there was no significant difference in the mean outcomes of length of the sagittal suture within the different age ranges in the female and male individuals.

Table 4: Mean length of sagittal suture in each age group (Females) (n=83)

Age group (in years)	Mean length (in cm)	Std. dev.	Minimum length (in cm)	Maximum length (in cm)	P value (as per Krusal-Wallis test)
20-29	12.12	0.84	10.50	13.70	0.222 (NS)
30-39	12.81	0.51	11.70	13.70	
40-49	12.32	0.73	11.00	13.00	
50-59	12.71	0.85	11.50	13.70	
60-69	12.54	0.71	11.00	13.50	
70-79	12.40	0.58	11.60	13.30	
80-89	12.48	0.60	12.00	13.40	
90-99	12.25	0.35	12.00	12.50	

Table 5: Mean length of sagittal suture in each age group (Males) (n=317)

Age group (in years)	Mean length (in cm)	Std. dev.	Minimum length (in cm)	Maximum length (in cm)	P value (as per Krusal-Wallis test)
20-29	12.68	0.74	11.00	14.20	
30-39	12.74	0.75	11.00	14.50	
40-49	12.90	0.69	11.00	14.20	
50-59	12.73	0.76	11.10	14.60	0.222 (NS)
60-69	12.70	0.71	10.00	14.00	
70-79	12.84	0.55	12.00	14.00	
80-89	12.72	0.38	12.30	13.50	
90-99	—	—	—	—	

Table 6: Sex-wise mean length of sagittal suture:

Sex (N=400)	Mean length (in cm)	Std. dev.	Minimum length (in cm)	Maximum length (in cm)	P value (as per Mann Whitney U test)
Female (n=83)	12.42	0.74	10.50	13.70	0.0001
Male (n=317)	12.76	0.71	10.00	14.60	(S)

Table 7: Findings of present study as compared with those of previous researchers:

Sr. No.	Name of the worker	Method of measuring length of Sagittal Suture	Males			Females		
			N	Mean length (in cm)	SD	N	Mean length (in cm)	SD
1	Rao et al[23]	Curvilinear length	87	12.92	0.77	—	—	—
2	Narasimhamurthy et al[21]	Straight length	50	12.41	0.74	50	11.93	1.01
3	Sobh and Gheat[3]	Curvilinear length	48	11.9	1.6	32	10.8	1.6
4	Present study	Curvilinear length	317	12.76	0.71	83	12.42	0.74

Thus, age was ruled out as a confounding factor in the current study population.

For the 83 female crania examined, the minimum length of sagittal suture was 10.5 cm while the maximum length was 13.7 cm with mean length being 12.42 ± 0.74 cm. For the 317 male crania examined, the minimum length of sagittal suture was 10 cm while the maximum length was 14.6 cm with mean length being 12.76 ± 0.71 cm. On applying Mann-Whitney U test (p-value= 0.0001, significant), we found that the mean length of the sagittal suture was significantly higher among males as compared to females (Table 6).

DISCUSSION

Since bones resist put refaction and destruction for a long time, they are a reliable source to determine age, sex, race and stature of the individual. The cranium is frequently the best preserved portion of the recovered skeleton.[9] It is due to its relatively higher resistance to environmental and animal destruction than other bones. The pelvis and the skull are known to be the most sexually dimorphic bones in the skeleton.[10] According to Krogman, sexing can be 90% accurate by skull alone.[11] The fact that sexual dimorphism exists between male and female human skulls morphologically as well as morphometrically is very well documented by numerous researchers.[12-17]

Cranial sutures help us estimate the age, origin, ancestry, sex (to some extent), identity and stature.[18] It is a well known fact that cranial sutures fuse earlier in males as compared to females[1,19] but some researchers do not agree with this generalisation.[18,20]

Narasimhamurthy *et al*[21] and Talokar and Lade[22] recommended bregma-lambda length (BLL) as a measurement for sex estimation. However, these studies measured the straight distance between bregma and lambda using a slide calliper rather than the length of the sagittal suture along its curvature, as was done in the present study. Their results, also pointed that sagittal suture measurements can be a helpful tool in sex estimation.

Sobh and Gheat in their study used the curvilinear lengths of coronal and sagittal sutures for determining sex. They showed that the combined length of the coronal and sagittal sutures was the best sex discriminator; followed by coronal suture length; and sagittal suture length. Furthermore, they developed three regression models to predict sex from these suture lengths. If the suture length (s) is (are) applied in the formula and the result of the equation is higher than a cut-of value, the sex was predicted to be male. The highest accuracy could be obtained by the equation that included the lengths of the coronal and sagittal sutures together (76% accuracy); followed by coronal suture length (75% accuracy); then the sagittal suture length (71% accuracy).[3]

Table 7 shows us the findings of other studies and the comparison with our study. In all the studies, it is found that the length of sagittal suture is greater in males than in females. As of now, we could not find any study in the literature where the opposite or contradictory findings were established.

Current study is limited by the fact that the number of female individuals in our sample size is considerably less as compared to their male counterparts. Therefore, in future such study should be performed on equal numbers of females and males. Secondly the method used for measurement can have measurement and observation errors and hence in future studies, to rule out these errors, sophisticated instruments which can be calibrated should be used.

CONCLUSION

Curvilinear length of sagittal suture is more in males as compared to in females, and hence it can be considered a reliable predictor for determination of sex.

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REFERENCES

1. ***Reddy KSN. Murty OP. Identification.*** *In: The Essentials of Forensic Medicine & Toxicology. 34th edition. New Delhi (India): Jaypee Brothers medical publishers. 2017. p.55-80.*
2. ***Khandare SV, Bhise SS, Shinde AB.*** *Age estimation from cranial sutures–a Postmortem study. International Journal of Healthcare and Biomedical Research. 2015 Apr; 3(3):192-202.*
3. ***Sobh ZK, Gheat AM.*** *Coronal and sagittal suture lengths as novel measurements for sex identification in a sample from the Egyptian population. Forensic Science, Medicine and Pathology. 2021 Mar;17(1):19-26.*
4. ***Quincey D, Carle G,*** *Alunni V, Quatrehomme G. Difficulties of sex determination from forensic bone degraded DNA: A comparison of three methods. Sci Justice. 2013;53:253–60.*
5. ***Latham K, Miller J.*** *DNA recovery and analysis from skeletal material in modern forensic contexts. Forensic Sci Res. 2019;4:51–9.*
6. ***Spradley MK, Jantz RL (2011)*** *Sex estimation in forensic anthropology: skull versus postcranial elements. J Forensic Sci 56:289– 296.*
7. ***Adams BJ, Byrd JE (2002)*** *Interobserver variation of selected postcranial skeletal measurements. J Forensic Sci 47(6):1193–1202.*
8. ***Steyn M, İşcan MY (1997)*** *Sex determination from the femur and tibia in South African whites. Forensic Sci Int 90(1–2):111–119.*
9. ***Brooks ST.*** *Skeletal age at death: the reliability of cranial and pubic age indicators. American Journal of Physical Anthropology. 1955 Dec;13(4):567-97.*
10. ***Selliah P, Martino F, Cummaudo M, Indra L, Biehler-Gomez L, Campobasso C, et al.*** *Sex estimation of skeletons in middle and late adulthood: reliability of pelvic morphological traits and long bone metrics on an Italian skeletal collection. Int J Legal Med. 2020;134:1683–90.*
11. ***Krogman WM, Iscan MY.*** *Skeletal age: Cranium. In: The Human skeleton in Forensic Medicine. 2nd edition. Springfield (USA): Charles C Thomas Publishers. 1986.*
12. ***Uytterschaut HT.*** *Sexual dimorphism in human skulls. A comparison of sexual dimorphism in different populations. Human Evolution. 1986 Jun;1:243-50.*
13. ***Paiva LA, Segre M.*** *Sexing the human skull through the mastoid process. Revista do Hospital das Clínicas. 2003;58:15-20.*
14. ***Lalwani M, Yadav J, Arora A, Dubey BP.*** *Sex identification from cranial capacity of adult human skulls. Journal of Indian Academy of Forensic Medicine. 2012;34(2):128-31.*
15. ***Sarač-Hadžihalilović A, Ajanović Z, Hasanbegović I, Šljuka S, Rakanović-Todić M, Aganović I, Prazina I, Kapo SM, Hadžiselimović R.*** *Analysis of gender differences on pyriform aperture of human skulls using geometric morphometric method. Folia Morphologica. 2022;81(3):707-14.*
16. ***Shanthi CH, Lokanadham S.*** *Morphometric study on foramen magnum of human skulls. Medicine Science. 2013;2(4):792-8.*
17. ***Sherif N, Sheta A, Ibrahim M, Kaka R, Henaidy M.*** *Evaluation of the paranasal sinuses dimensions in sex estimation among a sample of adult Egyptians using multidetector computed tomography. J*

Forensic Radiol Imaging. 2017;11:33–9.

18. ***Manivasagam M.***
Age Estimation from Fusion of ecto cranial (Coronal, Sagittal, Lambdoid, Temporal) sutures in humans: A study in bodies during autopsy to prove/disprove ages of sutural closure used in routine practice [Internet]. [Tirunelveli (India)]: The Tamil Nadu Dr. M. G. R. Medical University, Chennai. April 2015. Available from: http://www.repository-tnmgrmu.ac.in/7546 (Accessed on 17 June 2022).

19. ***Rentoul E, Smith H, Editors. 1973.***
Medical Jurisprudence and Toxicology. 13th edition. Churchill Livingstone. p80.

20. ***Millard, AB.***
Age assessment from cranial suture closure (unpublished thesis). San Marcos (Texas): Texas State University; 2011. [Internet]: Available from: https://digital.library.txstate.edu/handle/10877/4275. (Accessed on 29 June 2022).

21. ***Narasimhamurthy S, Kumar R, Manjunath T, Kuppast N, Umesh S, Shradha Iddalgave R.***
Reliability of bregma-lambda length measurements in identification of sex of skull. Sch J App Med Sci. 2015;3:1467–70.

22. ***Talokar S, Lade S.***
Sexual dimorphism of human skull by different parameters Int J Sci Res. 2015;4:614–6.

23. ***Rao P, Menezes T, Kanchan T, Sowmya J, Yoganarasimha K, Aswinidutt R***.
Estimation of stature from cranial sutures in a South Indian male population. Int J Legal Med. 2009;123:271–6.

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Estimation of Age of Abrasion by Histopathology Examination: A Cross-Sectional Study

Shikha Shrivastava[1], Prateesh Shukla[2], Yashwant Kumar Singh[3], Rajneesh Kumar Pandey[4], Shashidhar Prasad Garg[5], Jaya Vashisht[6]

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ABSTRACT

Context: In India, abrasions are usually dated by the naked-eye observation of gross changes. Various researches consider the dating of abrasion by naked-eye examination as an uncertain and variable method. This may have significant medical and legal ramifications. To improve the accuracy of the dating of abrasion, histopathology profiling has been suggested.

Aims: To estimate the age of abrasion by histopathology examination.

Settings and Design: This cross-sectional study was conducted from 1st January 2021 to 30th June 2022.

Methods and Materials: Total 102 abrasions from subjects aged 4 to 80 years were correlated with the time frame of the occurrence of different microscopic changes that follow the abrasion. Abrasions ranging from 0.02 hours to >336 hours were studied, and based on the duration of infliction, abrasions were divided into 10 groups. The representative area of abrasion with adjacent normal skin with an underlying soft tissue of thickness 0.5 cm to 1 cm was dissected and a control sample was taken of intact skin and preserved in 10% formalin solution for fixation. The specimen was processed, and a histopathology slide was prepared and examined. Routine haematoxylin & eosin (H&E) staining done. Van Gieson's stain was used to confirm the presence of collagen.

Statistical analysis used: Data were analysed using SPSS version 20.0 software. P<0.05 was considered significant. Descriptive data were expressed as frequency; for the age group of abrasions (quantitative data), mean and SD were calculated; Pearson's chi-square test of independence was used to compare the microscopic changes in abrasion with the age of infliction.

Results: A significant relationship was observed between the age of abrasion and histopathology findings (X^2_{81}=552.92, P<0.001).

Conclusions: The reliability and accuracy of dating of abrasion increases if a histopathology examination is performed along with gross examination. To opine the age of injury accurately, the autopsy surgeon should subject the samples to histopathology examination.

Keywords: Abrasion; Age of abrasions; Autopsy; Histopathology.

Key Messages: To opine the age of abrasion accurately, the autopsy surgeon should subject the samples to histopathology examination.

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INTRODUCTION

The determination of the age of an injury is one of the most important aspects of medico-legal examination. Significant medical and legal ramifications could result from their interpretation, such as, the inclusion or exclusion of a suspect as a criminal offender.[1] In forensic autopsy practise, injuries due to blunt impact are frequent, and proper interpretation of wounds is crucial for reliable medical testimony.[2] Among blunt traumas, abrasion is the most common,[3] and it is the most important tool for determining the age of the injury.

The dating of injuries has been a topic of disagreement among researchers. In India, injuries are usually dated by naked eye examination.[4] Colour changes in abrasion are frequently used for estimating the age of injury; however, some authors consider it as an uncertain and variable method for dating the wound due to observer bias. To improve the accuracy of the dating of abrasion, histopathology profiling has been suggested.[4,5]

Hence, this research was conducted to date an abrasion by histopathology examination.

MATERIALS AND METHODS

This cross-sectional study was conducted between 1st January 2021 and 30th June 2022 after obtaining ethical clearance from the Institutional Ethics Committee (IEC).

The study population was dead bodies brought by the police for a medico-legal autopsy. Dead bodies having a well demarcated abrasion and a known time of infliction were included. Dead bodies with infected abrasions and dead bodies in the state of decomposition were excluded from the study.

According to the selection criteria, 102 cases, between 1 and 80 years were selected for the study. Written informed consent to collect skin samples of representative areas of abrasions, with adjacent normal skin, along with control samples from nearer tissue, and their histopathology examination, was obtained from relatives accompanying the deceased. Information regarding the time of injury and death, hospitalisation, and associated comorbidities were noted. Based on the age of infliction, abrasions were grouped under 10 different time intervals i.e. ≤12 hours, 13 to 24 hours, 25 to 48 hours, (2nd day), 49 to 72 hours (3rd day), 73 to 96 hours (4th day) 97 to 120 hours (5th day), 121 to 144 hours (6th day), 145 to 168 hours (7th day) 169 to 336 hoyrs (8-14 days), and > 336 hours (>2 weeks).

The representative area of abrasion with adjacent normal skin with an underlying soft tissue of thickness 0.5 cm to 1 cm was dissected and a control sample was taken of intact skin and preserved in 10% formalin solution for fixation. The specimen was processed, slide prepared, and examined. Routine haematoxylin & eosin (H&E) staining done. Van Gieson's stain was used to confirm the presence of collagen. After staining, the slides were viewed under an Olympus microscope with Magvision software, and the findings were observed and recorded for both the sample and control.

Data were analysed using SPSS version 20.0 software. P<0.05 was considered significant. Descriptive data were expressed as frequency. For the age group of abrasions (quantitative data), mean and SD were calculated. Pearson's chi-square test of independence was used to compare the microscopic changes in abrasion with the age of infliction.

RESULTS

In this cross-sectional study, the sample size was 102 with age range of the study subjects was from 4 years to 80 years. Among 102 cases, 84 (82.35%) were male and 18 (17.65%) were female. The abrasions were most commonly observed in the age group 31 to 40 years (25/102, 24.51%) followed by 21 to 30 years (24/102, 23.53%).

In our study, edema formation was the most common (37/102, 36.27%) and margination of polymorph cells was the least common (1/102, 0.98%) microscopic findings. In our study, postinfliction congestion of vessels and haemorrhage was the first observed microscopic change (range 0.5–5 hours). Edema formation was observed earliest from 0.02 hours to the latest up to 35.75 hours. After that, polymorphs dominate the microscopic profile with margination (5.3 hours), early polymorph infiltration (range 1.67–32 hours), and predominant polymorph infiltration (range 12.05–29.08 hours). Subsequently, mononuclear cell infiltration (range 27.08–69.05 hours) and appearance of fibroblasts (range 72.17–92.17 hours) was observed. Granulation tissue deposition was seen from 100.42 to 165.67 hours postinfliction. Collagen was observed microscopically from 157 to 333.33 hours. The last phase of healing was the regression phase, which was seen in abrasion >336 hours old.

In our study, half of the cases (51/102, 50%) had an abrasion of age ≤12 hours (mean 3.26, SD 2.91). In abrasions ≤12 hours, edema was the most common microscopic finding (36/51, 70.59%), and margination and early infiltration of polymorphs were also seen. Between 13 and 24 hours (mean 16.82, SD 3.22) after injury, all the abrasions showed predominant infiltration by polymorphs. On the second day (mean 32.75, SD 4.67 hours) mononuclear cells were seen in the majority of cases (5/9, 55.56%). Edema formation and polymorph cells were seen microscopically in the remaining cases (4/9, 44.44%). All the abrasions on the third day (mean 63.33, SD 5.39 hours) and the fourth day (mean 82.39, SD 8.54 hours) postinfliction showed mononuclear infiltration and appearance of fibroblasts, respectively. Granulation tissue deposition was observed in all abrasions on the fifth and sixth days, and the majority (4/5, 80%) of abrasions on the seventh day. Collagen formation was observed microscopically in all abrasions from 8th to 14th days (mean 240.33, SD 70.98 hours). Regression in abrasion was seen only after 14 days (336 hours).

In this study, a statistically significant relationship between the age of abrasion and histopathology findings was found (X^2_{81}=552.92, P<0.001).

Table 1: Distribution of cases by Histopathology Findings

Histopathology Findings	No. of cases, N (N%)	Age of Abrasion, Mean (SD) (hours)
Congestion/Haemorrhage	5 (4.9%)	1.79 (1.86)
Edema formation	37 (36.27%)	3.43 (5.93)
Margination of Polymorph cells	1 (0.98%)	5.3 (0)
Early Polymorph infiltration	11 (10.78%)	10.91 (9.76)
Predominant Polymorph infiltration	7 (6.86%)	18.57 (5.49)
Mononuclear cell infiltration	8 (7.84%)	45.05 (15.94)
Appearance of Fibroblast	8 (7.84%)	82.39 (8.54)
Granulation tissue deposition	12 (11.76%)	127.65 (23.84)
Collagen formation	8 (7.84%)	229.92 (72.02)
Regression phase	5 (4.9%)	664.88 (345.89)
Total	102 (100%)	79.48 (166.06)

Table 2: Distribution of cases by Age of Abrasion and Histopathology Findings

Age of Abrasion	No. of cases (n)	Age of Abrasion Mean (SD)	Histopathology Findings	No. of cases (n)
≤12 h	51	3.26 (2.91) h	Congestion/Haemorrhage	5
			Edema formation	36
			Margination of Polymorph cells	1
			Early Polymorph infiltration	9
13 to 24 h	6	16.82 (3.22) h	Predominant Polymorph infiltration	6
25 to 48 h (2nd day)	9	32.75 (4.67) h	Edema formation	1
			Early Polymorph infiltration	2
			Predominant Polymorph infiltration	1
			Mononuclear cell infiltration	5
49 to 72 h (3rd day)	3	63.33 (5.39) h	Mononuclear cell infiltration	3
73 to 96 h (4th day)	8	82.39 (8.54) h	Appearance of Fibroblast	8
97 to 120 h (5th day)	5	105.57 (6) h	Granulation tissue deposition	5
121 to 144 h (6th day)	3	126.85 (7.78) h	Granulation tissue deposition	3

table cont....

145 to 168 h (7th day)	5	156.09 (9.55) h	Granulation tissue deposition	4
			Collagen formation	1
169 to 336 h (8th to 14th day)	7	240.33 (70.98) h	Collagen formation	7
>336 h (>2 wks)	5	664.88 (345.89) h	Regression phase	5
Total	102	79.48 (166.06) h		102

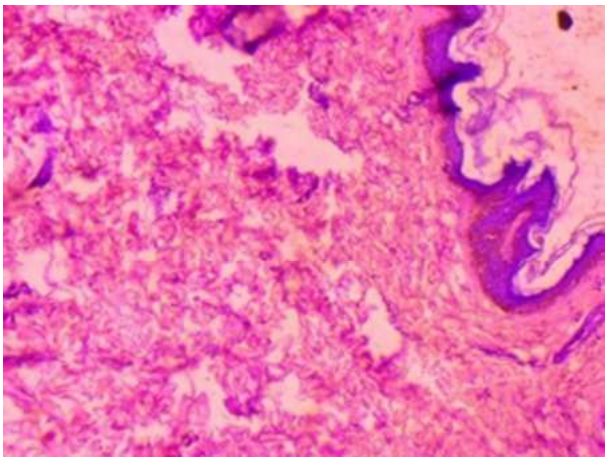

Fig. 1: Edema, congestion, and haemorrhage, H&E (10x).

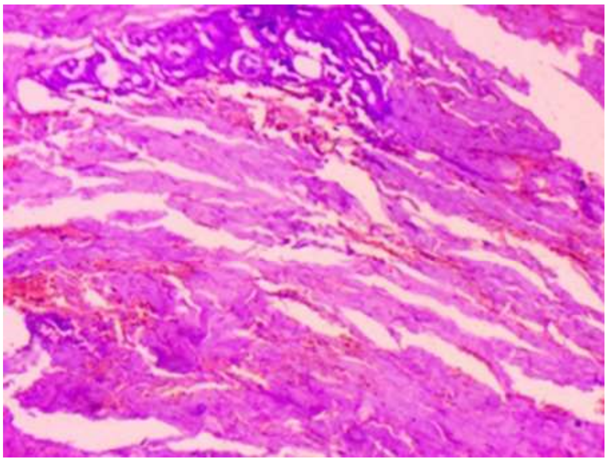

Fig. 2: Polymorph infiltration, H&E (10x).

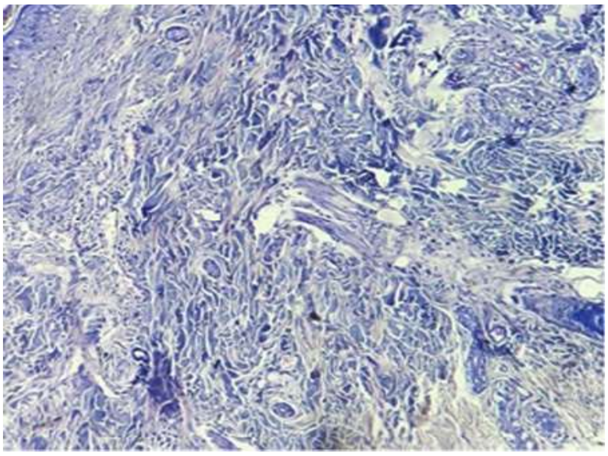

Fig. 3: Mononuclear cells, H&E (10x).

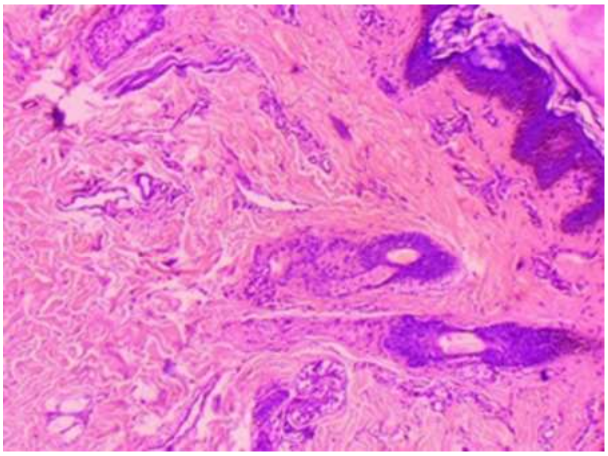

Fig. 4: Fibroblast cells, H&E (10x).

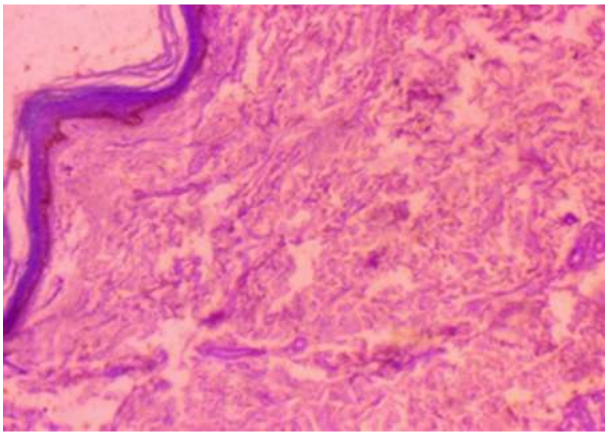

Fig. 5: Granulation tissue, H&E (10x).

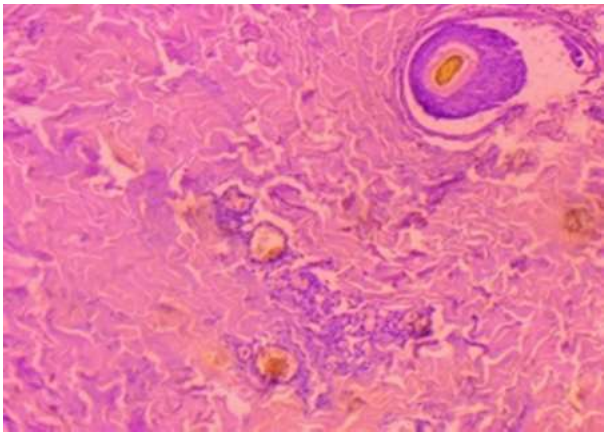

Fig. 6: Collagen, Van Gieson (10x).

DISCUSSION

Sample size in our study (N=102) was higher compared to other studies.[4–10] We observed a male preponderance (M:F: 4.67:1) similar to other researchers.[4,5,7–11] The observed male preponderance can mainly be attributed to the fact that men are more prone to injuries since they are more involved in outdoor activities such as driving vehicles, labour workers, etc.

In our study, the age range of the study subjects was from 4 years to 80 years. The age range of subjects in other research was from 1 year to more than 60 years.[4,7,9–11] A few research did not include extreme age groups and included subjects only between the ages of 18 and 60 years.[5,8]

We observed congestion of vessels and haemorrhage in abrasions from 0.5 to 5 hours after wounding. Research reported haemorrhage and/or congestion of vessels in the majority abrasion that were 0-4 hours old, supporting our findings.[4,5,10]

Edema formation, in our study, was seen microscopically at mean 3.43 (SD 5.93; range 0.02–35.75) hours. In a few studies, edema was observed in 0 hour to 4 hours old abrasion.[4,5] Although the observations in these research were similar to our study, the sample size in this group was too small to compare with our study or to draw any meaningful conclusion.

In this study, margination of polymorph cells was observed only in one abrasion aged 5.3 hours, such a small sample size in this group prevented us from drawing any meaningful inference. However, research and textbooks reported an earlier margination of polymorph cells in the majority of abrasions that were 0 to 4 hours old.[4,5,10,12]

We found early polymorph infiltration from 1.67 to 32 hours (mean 10.91, SD 9.76). Our observations were in agreement with the research[4,5,10] that found early polymorph infiltration in the majority of cases in 4 to 12 hours old abrasions. Relatively earlier appearance of polymorph infiltration in a perivascular fashion, from 2 to 6 hours, was quoted by one author,[13] which is in the purview of our finding. However, the earliest appearance of neutrophils, at about 20 to 30 minutes after wounding, was reported in one research.[14]

We observed predominant polymorph infiltration between 12.5 and 29.08 hours. Our observation was in agreement with the studies[4,5,10,15] that found predominant polymorph infiltration in the majority of cases between 12 hours and 24 hours old abrasions. Contrary to the above research, Sharma *et al.*[6] observed the earliest polymorph infiltration at 7 hours and the latest up to 3 days. A progressive increase in polymorphs was observed from 12 hours to 18 hours[13] and from 24 to 72 hours[4,10] in a few studies. In our research, we did not study the progressive increase in polymorph infiltration.

Mononuclear cell infiltration, in the majority of cases, was reported in studies, after 24 hours up to 72 hours of wounding.[4,5,10] These researches are in agreement with our findings (range 27.08-69.05 hours). Compared to our observation, a few researchers reported an earlier infiltration of mononuclear cells at 13 hours[6] and at 20 hours[16] respectively.

We found fibroblasts to appear between 72.17 and 92.17 hours. A few research reported the appearance of fibroblasts in the majority of cases between 24 hours and 6 days, which is a wider range compared to ours. However, in these studies, the sample size in this group was small to draw meaningful conclusions.[4,5,10] Another research also reported an earlier fibroblastic proliferation, from 27 hours onwards.[6]

We observed granulation tissue formation between 100.42 and 165.67 hours. Similar to our study, research has found that the majority of 4 to 6 days old abrasions show granulation tissue formation.[4,5,10] In contrast to our study, Siddiqui *et al.*[5] observed granulation tissue from 24 hours up to more than 2 weeks. A few authors have quoted granulation tissue formation in 5-8 days.[12,13] Betz P[16] quoted an earlier appearance at about 3 days after wound infliction.

We found collagen tissue in abrasion between 157 and 333.33 hours. Similar to our study, other researchers have observed collagen formation in the majority of the abrasions that were 7-14 days old.[4,5,10] In contrast, Sharma *et al.*[6] observed collagen formation that starts after the third day and persists up to 25 days. Siddiqui *et al.*[5] observed collagen formation from 4 days to more than 2 weeks. Saukko P[12] and Ross *et al.*[15] also quoted that, at 3 to 6 days collagen formation begins and later increases in density.

Our observations were supported by Ross *et al.*,[15] who observed the regression phase at 14 days. A similar observation was noted in other research[4,5,10] in which the majority of abrasions showed regression in more than 2 weeks postinfliction. Other research[4,10] observed that the earliest regression phase was observed at 9 days and was more common in injuries more than 2 weeks old.

In contrast to our study, Siddiqui *et al.*[5] observed an earlier regression phase from 7 days up to more than 2 weeks. Dimaio[13] quotes that the regression phase will start by the 12th day.

This study found a statistically significant relationship between the age of abrasion and histopathology findings (X^2_{81}=552.92, P<0.001). A similar statistical significant relationship between the two was reported by Vinay J *et al.* (X^2_{24}=99.37, P<0.001).[4]

CONCLUSION

We found an ordered and sequential appearance of cells in healing abrasions. Congestion of vessels and haemorrhage were seen in abrasions that were <5 hours old. Edema to present up to 35.75 hours. Polymorph to appear earliest at 1.67 hours, and predominant polymorph infiltration up to 29.08 hours. On the third day (27.08–69.5 hours) after wounding, mononuclear cells were visible microscopically. On the fourth day (72.17–92.17 hours) fibroblast appears. From the fifth to seventh day, deposition of granulation tissue occurs. Collagen formation was seen in abrasions between 157 and 333.33 hours (7th to 14th days). Regression phase starts only after 14 days. The relationship between the age of abrasion and histopathology findings was found to be statistically significant (X^2_{81}=552.92, P<0.001).

LIMITATIONS

Because of random sampling, the majority of samples in our study were from cases brought within 6 hours of wounding.

RECOMMENDATIONS

Naked eye examination (subjective) of gross changes in abrasions, gives only a rough estimate regarding the age, hence, subjecting the samples to histological examination for corroboration is recommended. Histopathological correlation for dating of abrasions is particularly useful in sensitive cases that demand a more accurate determination of the age of the injury. Research with a larger sample size, to improve external validity, is recommended.

REFERENCES

1. ***Pilling ML, Vanezis P, Perrett D, Johnston A.*** *Visual assessment of the timing of bruising by forensic experts. Journal of forensic and legal medicine. 2010;17(3):143-149.*
2. ***Simon LV, Lopez RA, King KC.*** *Blunt force trauma. Published online 2022. https://www.ncbi.nlm.nih.gov/books/NBK470338/*
3. ***Au Y, Laforet M, Talbot K, Wang SC.*** *Skin and wound map from 23,453 nursing home resident records: Relative prevalence study. Journal of Medical Internet Research Dermatology. 2018;20(10).*
4. ***Vinay J, Harish S, Mangala GSR, Hugar BS.*** *A study on postmortem wound dating by gross and histopathological examination of abrasions. The American Journal of Forensic Medicine and Pathology. 2017;38(2):167-173.*
5. ***Siddiqui MAM, Parvathi K, Khan MT, Reddy MN.*** *Histopathological study of blunt force injuries in relation to time since death. International Journal of Contemporary Medical Research. 2016;3(9):2780-2783.*
6. ***Sharma A, Dikshit PC, Aggrawal A, Mandal AK.*** *A postmortem study of histopathological findings to determine the age of abrasion and laceration. Journal of Forensic Medicine and Toxicology. 2010;27(1):43-46.*
7. ***Kumar L, B. V. C, Agrawal SS, Bastia BK.*** *Age related changes in mechanical and thermal injuries - a post mortem study. Journal of Indian Academy of Forensic Medicine. 2011;33(2):149-151.*
8. ***Saxena D, Nigam MK, Mishra PK, Tomar JS.*** *Age estimation of abrasion by their colour changes. Indian journal of forensic and community medicine. 2018;5(2):114-118.*
9. ***Mangeshkar A, Varghese PS.*** *An evaluation of colour change in abrasion and its correlation to time: A cross-sectional study from a tertiary care centre. Medico-Legal Update. 2019;19:1.*
10. ***Vijay Kumar A, Gowda N, Shivaramu MG, U. K.*** *Analysis of wound dating by gross and histopathological examination-a postmortem cross-sectional study. Indian journal of forensic and community medicine. 2020;5:114-118.*
11. ***Sandhu SS, Gorea RK, Gargi J, Garg A.*** *Age estimation of injury from abrasion - a clinical study from north india. Journal of Punjab Academy of Forensic Medicine & Toxicology. 2009;9(2):76-81.*
12. ***Saukko P, Knight B.*** *Knight's forensic pathology. In: 4th ed. CRC Press; 2016:133-165.*
13. ***DiMaio VJ, Dimaio D.*** *Forensic pathology. In: 2nd ed. CRC Press; 2001:94-98.*
14. ***Betz P.*** *Histological and enzyme histochemical parameters for the age estimation of human skin wounds. International Journal of Legal Medicine. 1994;107(2):60-68.*
15. ***Ross R, Benditt EP.*** *Wound healing and collagen formation. I. Sequential changes in components of guinea pig skin wounds observed in the electron microscope. The Journal of biophysical and biochemical cytology. 1961;11(3):677-700.*
16. ***Betz P.*** *Pathophysiology of wound healing. In: Payne JJ, Busuttil A, Smock W, eds. Forensic Medicine Clinical and Pathological Aspects. Greenwich Medical Media Ltd; 2003:83-85*

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Lip Prints as an Early Indicator of Different Malocclusions

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ABSTRACT

Introduction: The goal of the current investigation was to see if there was any correlation between skeletal malocclusions and lip print patterns.

Settings and Design: Hospital based, prospective, observational, cross-sectional study.

Materials and Method: The study was conducted on 120 subjects, divided into 3 groups Skeletal Class I, Class II, and Class III based on ANB angle, Beta angle, and Wits. For the assessment of lip print patterns, they were classified according to the Tsuchihashi classification system.

Statistical analysis: The chi-square test was used to study differences in the groups.

Results: It was noted that the most prevalent lip pattern was Type I while; the least was the Type V pattern. A Type III lip pattern was absent. There was a significant correlation between Type I lip pattern and Skeletal Class III malocclusion. Also, there were significant gender differences in lip print patterns in skeletal class I malocclusion with no differences in skeletal class II and class III malocclusion.

Conclusion: Lip prints can be a useful aid in predicting the type of skeletal malocclusion as they develop early in life, therefore, can be successfully used for preventative and interceptive orthodontic procedures. Hence, lip prints can be used as early detectors of skeletal malocclusions.

Keywords: Lip prints; Skeletal malocclusion; Forensics.

Key message: Since the craniofacial skeleton and lips print both develop at the same embryonic stage, developmental variables that result in malocclusions may also be reflected in the lip print patterns.

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INTRODUCTION

The cornerstone of forensic science is the accurate identification of live or deceased people using their distinctive qualities and characteristics. The mouth is considered a multiplicity of options for forensic identification. In addition to teeth, soft oral and peri-oral tissue impressions can provide information.[1] The study of lip prints is termed cheiloscopy.[2] Every individual has a distinctive lip print that remains constant from the sixth week of fetal development until death. This implies that the pattern of lip wrinkles (also known as "lip prints") is comparable to that of thumbprints. According to several studies, lip prints can be used in forensic dentistry, similar to thumbprints.[3] A strong genetic predisposition has been observed by many authors.[4,5] The first 6–12 weeks of pregnancy are crucial for the entire development of the lip, alveolus, and palate. It is well established that any factor present throughout genetic expression will inevitably have an impact on all structures that grow during that time.[5] Hence, environmental elements that result in malocclusion during development should have an impact on the pattern of lip prints. This could imply a connection between skeletal malocclusion and lip-printed patterns.

Lip prints are established at a very early period[6]; hence, doctors would benefit by being able to forecast the type of malocclusion at a young age and gain more insight into the identity of the individual.

AIM AND OBJECTIVES

The aim of the present study was to find out whether there exists a relationship between lip prints and sagittal skeletal jaw relation in adults of age 18-25 years. The objectives of the study were to record and study the lip prints and lateral cephalograms of each sample in the study group, to correlate the recorded lip print patterns with the respective sagittal skeletal jaw relation and to determine if there exists any association between them.

MATERIALS AND METHOD

Study type and design

This is a prospective, observational, cross-sectional study was conducted in the Department of Orthodontics.

Sample size calculation

The sample size was calculated using G power software version 3.2.9. In this study, it was recommended that at a significance level of 0.05, and a power of 90%, the study should include 99 samples. Therefore, 120 participants were included in the study.

Participants

Convenient method of sampling was used for the study. The subjects who came to the Department for their treatment were included and Lateral Cephalograms were obtained as a pre-treatment record of the subjects, which were used in our study for classifying them into Skeletal Class I, II and III.

After screening 600 subjects from Jan 2022 to November 2022, based on the selection criteria, a total of 120 subjects were included in this study. The inclusion criteria were as follows: Subjects having normal lip mucosa with no developmental anomalies or lip trauma, presence of all the teeth up to second molars, subjects with Skeletal Class I, II and III sagittal jaw relationship, and normal growth pattern (FMA=25±50), were included in the study.

The subjects with known hypersensitivity to lipsticks, pathologies of lips, subjects who did not give the informed consents, previous history of orthodontic treatment, scarring of lips and congenitally missing or extracted teeth except third molars, were excluded from the study.

Ethical committee approval was obtained from the institutional committee (SDCRI/IEC/22/08), and Clinical Trials were registered at the Clinical Trials Registry of India (REF/2022/08/057070). Written informed consents were obtained from all the subjects before the start of the study.

The study sample was categorized into Class I, Class II, and Class III skeletal patterns based on ANB angle, beta angle, and Wits.[7] The study sample was divided into three groups:

Group A: Skeletal Class I malocclusion-If ANB angle is between 2 to 4 degrees, Wits appraisal (AO=BO in females & BO is ahead of AO by 1mm in males) and Beta angle is between 27 to 35 degrees (39 subjects; mean age-20.75±3.74 years; 22 males and 17 females).

Group B: Skeletal Class II malocclusion-If ANB angle is greater than 4 degrees, Wits appraisal (AO is ahead of BO) and Beta angle is less than 27 degrees (48 subjects; mean age - 20.32±2.44 years; 16 males and 32 females).

Group C: Skeletal Class III malocclusion-If ANB angle is less than 2 degrees, Wits appraisal (BO is ahead of AO) and Beta angle is more than 35 degrees[7] (33 subjects; mean age-21.32±2.65 years; 18 males and 15 females).

Method

Digital lateral cephalograms of all subjects were obtained in the natural head position (NHP) using a KODAK 8000 Digital Panoramic and Cephalometric X-ray system.

For each subject, lip prints were captured on white bond paper. The participants were instructed to rest on a dentist's chair while being examined for lip prints, and their lips were then cleansed with a moist cloth. Then, using a Bard-Parker knife, a piece of red lipstick was divided and placed in a dapper dish, from which a lip brush was applied. The participants were asked to rub both lips together to spread the lipstick. The bonded portion of the cellophane tape strip was placed over the lipstick, and a lip impression was created by first dabbing it in the centre and then uniformly pressing it toward the corners of the lips. For a lasting record, the cellophane strip has adhered to the white bond paper. A magnifying glass was then used to view the lip impressions.[8] Each measurement was performed to prevent cross-contamination.

The lip print designs were categorized according to Tsuchihashi's nine suggestions.[8] Similar to the work by Sivapathasundharam *et al*[2], the central portion of the lower lip (10 mm wide) was chosen as the study area for classification. By counting most lines in this area that resembled the Tsuchihashi classification, the lip print pattern was identified.

To reduce bias in the study

To reduce the methodology bias, all lip impressions were evaluated twice for their validity, once by the principal investigator and again by an orthodontist. The lip patterns, confirmed by both of them to be proper, were utilized in the study. Both investigators were blinded to the type of skeletal pattern in the subjects at the time of lip pattern analysis. To reduce measurement bias and increase the reliability of the study, 20 subjects were recalled 2 weeks apart by the principal investigator, and lip prints were retaken. Intraobserver reliability was calculated using the intraclass correlation coefficient, and it showed high reliability (97).

STATISTICAL ANALYSIS

Statistical analyses were performed using SPSS version 22.0, IBM, corp. Shapiro-Wilk test was used to assess the normality of the data. As the data was found to be normal, non-parametric test was used. The chi-square test was used for assessing the association of lip print pattern with gender, and comparing different lip print patterns in subjects having skeletal class I and class II malocclusion, skeletal class I and class III malocclusion, and skeletal class II and class III malocclusions. The frequency distribution for various lip print patterns with respect to different malocclusions was expressed in terms of number and percentage. Statistical significance was set at $p \le 0.05$.

RESULTS

Table 1 shows the prevalence of the lip print pattern in the subjects. Type I was the most common (41.7%) and Type V (0.8%) was the least common. Lip patterns were evaluated in different skeletal malocclusions, that is, skeletal class I, class II, and class III. In the skeletal class I group, the Type II lip pattern was the most prevalent (48.7%) (Table 2). In the skeletal class II group, Type II was the most prevalent (41.7%), and Type I lip pattern (10.4%) was the least (Table 3). In the skeletal class III group, the Type I lip pattern was the most prevalent (60.6%), whereas the Type V lip pattern was completely absent (Table 4).

Table 1: Prevalence of lip print patterns among the subjects

Patterns	Frequency	Percent
Type I	50	41.7
Type I	5	4.2
Type III	0	0
Type II	45	37.5
Type IV	19	15.8
Type V	1	.8
Total	120	100.0

Table 2: Distribution of lip print patterns in Skeletal Class I subjects

Pattern	Frequency	Percent
Type I	15	38.5
Type II	19	48.7
Type III	0	0
Type IV	4	10.3
Type V	1	2.6
Total	39	100.0

Table 3: Distribution of lip print patterns in Skeletal Class II subjects

Pattern	Frequency	Percent
Type I	15	31.3
Type I	5	10.4
Type II	20	41.7
Type III	0	0
Type IV	8	16.7
Total	48	100.0

Table 4: Distribution of lip print patterns in Skeletal Class III subjects

Pattern	Frequency	Percent
Type I	20	60.6
Type II	6	18.2
Type IV	7	21.2
Total	33	100.0

On evaluating the gender differences, it was noticed that subjects with skeletal class I showed significant Type II lip patterns (77.3%) in males and Type I (64.7%) lip patterns in females ($p<0.05$), while skeletal class II and Skeletal Class III showed non-significant gender differences in lip pattern ($p\geq0.05$) (Table 5).

Table 5: Gender wise distribution of lip print patterns among Skeletal class I, II & III subjects

Skeletal relation	Gender	Pattern of lip prints	Frequency	Percent	p-value
Class I	Female	Type I	11	64.7	
		Type II	2	11.8	
		Type IV	3	17.6	
		Type V	1	5.9	0.0013
	Male	Type I	4	18.2	
		Type II	17	77.3	
		Type IV	1	4.5	
Class II	Female	Type I	8	25.0	
		Type I'	4	12.5	
		Type II	14	43.8	
		Type IV	6	18.8	0.5828
	Male	Type I	7	43.8	
		Type I'	1	6.3	
		Type II	6	37.5	
		Type IV	2	12.5	
Class III	Female	Type I	9	60.0	
		Type II	2	13.3	
		Type IV	4	26.7	0.6897
	Male	Type I	11	61.1	
		Type II	4	22.2	
		Type IV	3	16.7	

$p\leq0.05$- significant

The chi-square test showed no significant difference in lip patterns in all subjects with skeletal classes I and II ($p>0.05$) (Table 6).

Table 6: Comparison of lip print patterns among Skeletal class I and Class II subjects

Pattern	Class I		Class II	
	Frequency	Percent	Frequency	Percent
Type I	15	38.5	15	31.3
Type I	0	0.0	5	10.4
Type II	19	48.7	20	41.7
Type IV	4	10.3	8	16.7
Type V	1	2.6	0	0.0
Chi-Square value	6.49			
p-value	0.16			

$p\leq0.05$- significant

Skeletal classes I and III showed a significantly higher ($p < 0.05$) proportion of Type I lip pattern in subjects with skeletal class III than in those with skeletal class I, while the proportion of Type II lip pattern was significantly higher ($p <0.05$) in subjects with skeletal class I than in those with skeletal class III (Table 7).

Table 7: Comparison of lip print patterns among Skeletal class I and Class III subjects

Pattern	Class I		Class III	
	Frequency	Percent	Frequency	Percent
Type I	15	38.5	20	60.6
Type I	0	0.0	0	0
Type II	19	48.7	6	18.2
Type IV	4	10.3	7	21.2
Type V	1	2.6	0	0.0
Chi-Square value	8.85			
p-value	0.03*			

* $p \leq0.05$ - Statistically significant

On comparing skeletal class II and class III, it was found that the proportion of Type I lip patterns was significantly higher ($p < 0.05$) in subjects with skeletal class III than in those with skeletal class II (Table 8).

Table 8: Comparison of lip print patterns among class II and Class III subjects

Pattern	Class II		Class III	
	Frequency	Percent	Frequency	Percent
Type I	15	31.3	20	60.6
Type I	5	10.4	0	0
Type II	20	41.7	6	18.2
Type IV	8	16.7	7	21.2
Type V	0	0.0	0	0.0
Chi-Square value	10.91			
p-value	0.012*			

* p≤0.05- Statistically significant

DISCUSSION

Development of the lip and alveolus occurs during early intrauterine life. Hence, any environmental or genetic factor affecting one structure will influence other structures too.[5] Our study was based on the assumption that since they have the same time and same embryonic origin[5], there should be some association between lip print patterns and skeletal malocclusions found in an individual.

There are different methods of recording lip prints in the literature[9] but in the present study, we used the most common method (lipstick cellophane technique), which provided good clarity and accuracy.

Regarding the prevalence of lip patterns in different skeletal malocclusions, our study showed that Type I and Type II were the most prevalent, and Type V was the least common lip pattern. Similar results were reported by Raghav P *et al.*[10] and Kaushal B *et al.*[11] However, our findings contradict those of Verghese *et al.*[12] and Tsuchihashi.[8] Type III lip pattern was not observed in the present study. This contradicts the results of many previous studies.[8,12] The most probable reason for these differences could be regional variations.

On assessing the gender differences in the pattern of lip prints, it was observed in our study that there was no significant gender difference in skeletal class II and class III malocclusion, which supports the fact that there might be no sexual dimorphism in lip patterns. Our findings were following those of Tsuchihashi[8] and Verghese *et al.*[12] However, there was a significant sex difference in skeletal class I malocclusion; Type II malocclusion was more common in males, and Type I malocclusion was more common in females. This was following the studies by Vahanwal *et al.*[1], Babu *et al.*[13], and Gondivkar *et al.*[14] These contradictory findings suggest that cheiloscopy should be used as a supplement to other techniques to determine sex (not as the sole method).

Both skeletal class I and class II subjects predominantly had Type I and Type II lip patterns, with no discernible difference between the groups when lip print patterns in various skeletal malocclusions were compared. Skeletal class III subjects, however, displayed Type I lip patterns that were significantly different from skeletal classes I and II. This finding shows that both lip prints and skeletal class III malocclusions exhibit strong inheritable tendencies. These results are in accordance with those of Raghav P *et al.*[10] and Jain S *et al.*[15] Our results contradict those of Aditi *et al.*[16] and Sindura A *et al.*[17] The reason for the conflicting results might be due to differences in the methodology and system of classification of lip prints used in the studies. Due to conflicting results on the use of lip prints for personal identification and their relationship to skeletal malocclusions, further extensive research is required in this direction.

LIMITATIONS

Due to the small sample size of our study, more research encompassing more ethnic groups and larger sample size is necessary to confirm the relationship between lip patterns and skeletal malocclusions. Another drawback of the study is that the etiology of malocclusion, which is determined by genetic, environmental, and local variables, has not been considered.

CONCLUSIONS

Our analysis led us to conclude that Type I lip patterns were the most common. Each patient's lip print pattern was noted and maintained in an individual database for personal identification. Skeletal classes I and II predominantly showed Type I and II lip patterns, respectively. Skeletal class III malocclusion and Type I lip patterns were significantly correlated. Lip prints can be a useful aid in predicting the type of skeletal malocclusion that develops early in life; therefore, they can be successfully used for preventative and interceptive orthodontic procedures. Hence, lip prints can be used as early detectors of skeletal malocclusions.

REFERENCES

1. ***Vahanwala SP, Parekh BK.*** *Study of lip prints as an aid to forensic methodology. J Indian Dent Assoc. 2000; 71:269–271.*
2. ***Sivapathasundharam B, Prakash PA, Sivakumar G.*** *Lipprints (cheiloscopy). Indian J Dent Res. 2001; 149:129 132.*
3. ***Sharma P, Saxena S, Rathod V.*** *Cheiloscopy; the study of lip prints in sex identification. J Forensic Dent Sci. 2009;1:24-27.*
4. ***Hirth L, Gottsche H, Goedde HW.*** *Lip prints—Variability and genetics.J Human Evol. 1977;6:709-710.*
5. ***King L, Harris EF, Tolley EA.*** *Heritability of cephalometric and occlusal variables as assessed from siblings with overt malocclusions. Am J Orthod Dentofacial Orthop. 1993;104:121–131.*
6. ***Kulkarni N, Vasudevan S, Shah R, Rao P, Balappanavar AY.*** *Cheiloscopy: A new role as a marker of sagittal jaw relation. J Forensic Dent Sci. 2012;4:6 12.*
7. ***Baik CY, Ververidou M.*** *A new approach of assessing sagittal discrepancies: The Beta Angle. Am J Orthod Dentofacial Orthop. 2004;126:100-105.*
8. ***Tsuchihashi Y.*** *Studies on personal identification by means of lip prints. Forensic Sci. 1974;3:233 248.*
9. ***Verghese AJ, Vidyullatha VS, Shashidhar CM.*** *A comparison of the methods for the recording of lip prints. Medico Legal Update –An Int J. 2010;10:62 63.*
10. ***Raghav P, Kumar N, Shingh S, Ahuja NK, Ghalaut P.*** *Lip prints: The barcode of skeletal malocclusion. J Forensic Dent Sci. 2013;5:110 117.*
11. ***Kaushal B, Mittal S, Aggarwal I.*** *Association of Lip Print Patterns with Sagittal Malocclusions in District Solan Population. Int J Res Health Allied Sci. 2018;4(1):75-81.*
12. ***Verghese AJ, Somasekar M, Babu RU.*** *A study on Lip prints types among the people of Kerala. J Indian Acad Forensic Med. 2010;32:6 7.*
13. ***Babu NC, Premalatha BR, Jude.J. Cheiloscopy:*** *A new aid for sex identification in forensic science. Indian J Forensic Odontol. 2009; 3: 131 136.*
14. ***Gondivkar SM, Indurkar A, Degvekar S, Bhowate R.*** *Cheilosopy for sex determination. J Forensic Dent Sci. 2009;1:56 60.*
15. ***Jain S, Saifee A.*** *Comparative Evaluation of Lip Prints Patterns in Gender and Different Musculoskeletal Malocclusion. Saudi J Oral Dent Res.2019; 4: 738-741.*
16. ***Aditi S, Tikku T, Khanna R, Maurya RP, Verma SL, Srivastava K, et al.*** *Cheiloscopy: Association of lip prints in different skeletal malocclusions. Int J Orthod Rehab. 2019;10:156-60.*
17. ***Sindura A, Setty JV, Srinivasan I, Jawa A.*** *Determination of Relationship between Lip Prints and Skeletal Malocclusion in Children of Age 9–14 Years. Int J ClinPed Dent. 2019;12:494-499.*

ORIGINAL ARTICLE

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Do Nutritional Status Parameters such as Body Mass Index & Mid Upperarm Circumference Need to be Taken into Account when Estimating Dental Age? A Cross-sectional study with Tooth Count as Variable

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ABSTRACT

Context: Age estimation is playing a very important role in the criminal justice system and also in the forensic human identification process. Over the past several decades, the scientific community has done extensive work on age estimation from biological markers of growth, the dental structure being one among them. The routine dental age estimation methods usually apply the mineralization and/or the eruption parameters of the developing dentition. Certain factors like the nutritional status and the socio-economic status of the individual also may influence dental development and eruption.

Aim: The objective of the study was to assess the link between the nutritional status and the dentition status of children and adolescents in the age range of 12 to 18 years.

Settings and Design: This is a cross-sectional population based, descriptive study.

Materials and Methods: The body mass index (BMI) and the mid-upper arm circumference (MUAC) values were measured to assess the nutritional status of the children with a mean age of 14.35 years (± 1.36). The oral examination was done to count the number of teeth present. The tooth count was compared with the BMI and the MUAC values of the children.

Results: The mean BMI of the study population was 17.36 Kg/m^2 ± 3.40 and the mean MUAC value was 21.53cm ± 2.93. There was a strong positive correlation between BMI and MUAC and a significant difference in the deciduous tooth count among the BMI categories. (χ^2 =12.161, df 3, $p<0.05$).

Conclusion: There is no significant association between BMI and deciduous tooth count in the study sample.

Keywords: Body mass index, Age estimation, Malnutrition, Tooth development, Mid upper arm circumference, Tooth count.

Key Messages: The BMI and MUAC values are markers of nutritional status in growing children. Though nutritional status has a link with the tooth development, the present study could not establish a significant association between BMI and deciduous tooth count in children in the age range of 12 to 18 years.

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INTRODUCTION

The mineralization of the teeth and skeletal structures are considered biological markers of growth, which is a physiological process in which nutrition plays a vital role. The nutritional status is thought to have a greater influence on tooth development in children.[1-3] Also, the mineralization status of teeth is regarded as an indicator of physiological maturity and skeletal development.[4,5] Other parameters like the timing of the emergence of teeth and the number of deciduous and permanent teeth at various ages have also been reported to demonstrate the link between dental development and physiological development in children.[6] The anthropometric parameters like height and weight reflect upon the growth and nutritional status of growing individuals. The body mass index (BMI), which is calculated using the above two anthropometric parameters is considered a reliable way of measuring or predicting the nutritional status of growing individuals.[7] The mid-upper arm circumference (MUAC) value is also accepted as a measure of nutritional status in children.[8] Reports have also revealed a significant correlation between nutritional status and the timing of dental emergence.[9] Most of the dental age estimation methods apply the mineralization status and eruption parameters of teeth for predicting age in forensic and human identification cases.[10] However, the parameters like nutritional status and socioeconomic status are overlooked while performing the dental age estimation of children. There is also a scarcity of scientific literature addressing the relationship between anthropometric parameters and nutritional status and its possible effect on dental development.[11] Hence, the present study was undertaken to assess the nutritional status of school children of known age and to determine its relationship with dentition status.

MATERIALS AND METHODS

The study subjects for this research comprised human subjects residing in the state of Gujarat, India. School children who were above 12 years but less than 18 years at the time of the survey were selected from August to November 2019. The school authorities were informed about the aims and objectives of the study and their permissions were obtained before the start of the survey. Approval was granted by the Institutional Ethics Committee of the principal author's dental institute. (Ref. No. IEC/GDCH/S.2/2019) The basic background information such as name, sex, date of birth, date of examination, and residential details of the children was recorded. The chronological age was determined as the difference between the date of birth and the date of recording the details. The height of the child was measured using a wall-mounted stadiometer (Thermocare®, India), which is constructed out of a ruler and a sliding horizontal headpiece that is adjusted to rest on the top of the head. The height was measured to the nearest 0.1 cm.[12] Care was taken to avoid the parallax error while recording the height. The weight of each child barefoot was measured to the nearest 0.1 kg using a portable electronic weighing scale (Hoffen®, Ace Incorporation, Jaipur) which was calibrated before use. Each child was instructed to stand straight so that the mass of the body is equally distributed between feet until the reading in the scale stabilized. The mid-upper arm circumference was measured using a flexible, inelastic color coded measuring tape (IS Indosurgicals®, India) The measure was taken in the patient's non-dominant arm, just at the mid-point between the acromion and the olecranon, in sitting or standing posture.[13] All the values were recorded twice by the same observer and the data was entered in the printed performa and later entered in the excel sheet. The body mass index (BMI) was calculated using the formula: BMI = Weight in kg / (Height in meter)^2. The height and weight and the MUAC measurements of 30 child patients visiting the author's institute was recorded twice by the same examiner prior to the start of the study in order to evaluate the intra-examiner measurement error. The values obtained during the first and second attempts were tested using paired t-test and also subjected to Dahlberg's formula. The oral clinical examination was conducted using the WHO diagnostic criteria.[14] The number of deciduous teeth in both arches were recorded. The data was analyzed using JASP computer software (Version 0.16.1).

Statistical Analysis:

The normality of the data was measured using the Shapiro-Wilks test. The descriptive statistics, Chi-square test, correlation coefficients, nonparametric Kruskal-Wallis test, Mann-Whitney test, and linear regressions were applied for the statistical analysis of the data.

RESULTS

The paired t-test to assess the intra-examiner error and the measurement error testing using Dahlberg's formula revealed an insignificant difference (p>0.05) in the mean values of the measurements obtained in the first and second attempt. In the present study a sample of 1104 school students aged 10 to 20 years with a mean age of 14.35 years ± 1.36 were included. The study subjects included 529 (47.9%) boys and 575 (52.1%) girls. The mean age of boys was 14.37 years ±1.37 and the mean age of girls was 14.32 years ±1.35. There was no significant difference in the chronological age between boys and girls. The Shapiro-Wilks test of normality revealed a non-normal distribution of age (W=0.981, p<0.001), BMI (W= 0.916, p<0.001), and MUAC (W=0.975, p<0.001) values in the overall subjects where 'W' is the test statistic. The mean height and the mean weight of the overall sample were 152.07cms ±9.78 and 40.48kg ±10.19 respectively and the calculated mean BMI was 17.36kg/m2 ±3.40 and the mean MUAC value was 21.53 cm ±2.93. The girls had significantly higher BMI and MUAC values than boys and the difference were highly significant. (Table 1 and 2, Fig. 1) The mean BMI and MUAC values in different age groups are shown in figure 2. The cross-tabulation of the age category with the BMI category is not showing a significant association between boys and girls. (Table 3) Age is positively correlated with BMI (r=0.172, P<0.001) and MUAC values (r= 0.221, P <0.001) but negatively correlated with deciduous tooth count (r=-0.295, P <0.001).

Table 1: Table showing the results of the descriptive statistics of BMI in boys and girls according to their age range category

Age category	Age range (Yrs.)	BMI (Kg/m2)								
		Boys			Girls			Total		
		n	Mean	SD	n	Mean	SD	n	Mean	SD
1	12.00-12.99	89	16.20	3.52	91	16.45	2.74	180	16.33	3.15
2	13.00-13.99	104	16.15	3.08	131	17.33	3.05	235	16.81	3.115
3	14.00-14.99	147	16.99	3.61	163	18.29	3.60	310	17.68	3.66
4	15.00-15.99	117	17.30	3.18	113	18.10	3.25	230	17.69	3.239
5	16.00-16.99	52	18.15	3.79	55	18.70	3.48	107	18.43	3.628
6	17.00-17.99	20	18.08	3.23	22	18.03	2.31	42	18.06	2.755
Total		529	16.92	3.45	575	17.77	3.29	1104	17.36	3.40

Abbreviations: [BMI = Body Mass Index]

Table 2: Table showing the results of the descriptive statistics of MUAC values in boys and girls according to their age range category

Age category	Age range	MUAC (Cm.)								
		Boys			Girls			Total		
		n	Mean	SD	n	Mean	SD	n	Mean	SD
1	12.00-12.99	89	20.897	3.312	91	20.522	2.589	180	20.707	2.966
2	13.00-13.99	104	20.17	2.948	131	21.004	2.459	235	20.635	2.713
3	14.00-14.99	147	21.195	3.206	163	22.325	2.767	310	21.789	3.032
4	15.00-15.99	117	21.784	2.75	113	22.157	2.514	230	21.967	2.638
5	16.00-16.99	52	22.99	3.21	55	22.258	2.519	107	22.614	2.886
6	17.00-17.99	20	23.645	3.139	22	22.218	2.017	42	22.898	2.678
Total		529	21.34	3.19	575	21.69	2.66	1104	21.53	2.93

Abbreviations: [MUAC= Mid Upper Arm Circumferance]

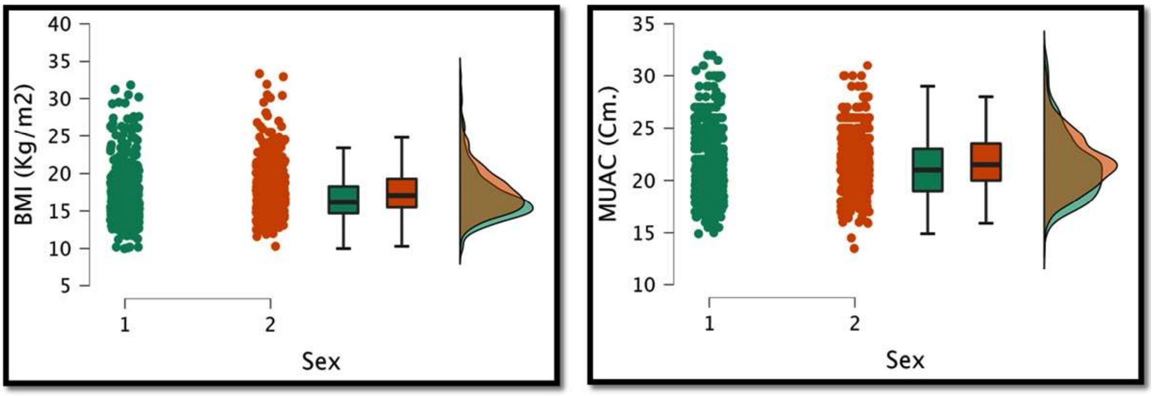

Fig. 1: Raincloud Plots of mean BMI and MUAC values between sexes (1 = Boys, 2 = Girls)

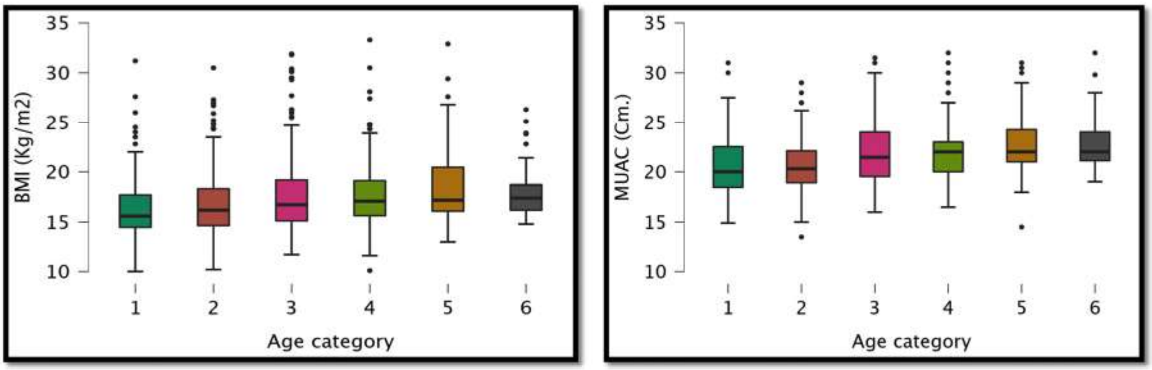

Fig. 2: Box Plot of the mean BMI and MUAC values among the age categories

Table 3: The table showing the distribution of the study subjects according to their BMI category.

BMI category	BMI range	Boys		Girls		Total		X^2	df	Sig*.
		n	%	n	%	n	%			
1	<18.5 (Underweight)	403	76.18	373	64.87	776	70.29			
2	18.5-24.99 (Normal)	104	19.66	185	32.17	289	26.18			
3	25.0-29.99 (Over weight)	18	3.40	11	1.91	29	2.63	24.077	3	0.000
4	>30 (Obese)	4	0.76	6	1.04	10	0.91			
	Total	529	100	575	100	1104	100			

*Chi square test significant at p<0.05; BMI = Body Mass Index.

Relationship between BMI and MUAC:

There is a strong overall significant correlation between BMI and MUAC values. (r=0.805, p<0.001). The regression equation derived with BMI as the dependent variable and the MUAC as the independent variable for the overall population is given below:

BMI = -2.744 + 0.934(MUAC)

with r^2 = 0.649 and standard error of estimate (See) = 2.017.

Male BMI = -2.027 +0.888 (MUAC)

r^2= 0.671 and standard error of estimate (SEE) = 1.98; P<0.001

Female BMI = -3.552 + 0.983 (MUAC)

r^2 = 0.630, standard error of estimate (SEE) = 2.00; P<0.001.

Deciduous tooth count

The deciduous tooth count in the overall sample ranged from 0 to 13. In the overall sample, 86.5%

were not having any deciduous teeth in their dentition. There was a significant difference in the distribution of the deciduous tooth count between boys and girls. (Table 4) The deciduous tooth count showed a significant negative correlation with anthropometric parameters like Height, weight, BMI, and MUAC values. The Kruskal Wallis test revealed a significant difference in deciduous tooth count between different age groups (χ^2= *117.34, df=5, P<0.001*) and with the BMI categories (χ^2= *12.161, df=3, P<0.05*). Only 16% of the underweight category children in the age range of 12 to 18 years were having one or more deciduous tooth/ teeth in their dentition. Out of the 39 overweight and obese children, only 3 (7.7%) were showing the presence of retained deciduous teeth. As there was a significant correlation between age and the deciduous tooth count and other anthropometric parameters, a linear regression model was prepared with age as the dependent variable and other parameters as the independent variables.

Table 4: Table showing the frequency distribution of the deciduous tooth count category in the study subjects.

Dec. tooth count category	Dec. tooth count	Boys		Girls		Total		X²	df	Sig.
		n	%	n	%	n	%			
0	Nil	447	84.499	508	88.348	955	86.504			
1	1-5 teeth	63	11.909	57	9.913	120	10.87			
2	5-10 teeth	13	2.457	5	0.87	18	1.63	5.936	3	0.115
3	>10 teeth	6	1.134	5	0.87	11	0.996			
Total		529	100	575	100	1104	100			

*Chi square test significant at p<0.05.

Age = 12.544-0.009 (BMI)+0.096 (MUAC)-0.178 (Dec. tooth count)

R = 0.310; r^2= 0.096; SEE = 1.300; P<0.001

Boys age = 12.700 - 0.025 (BMI) + 0.104 (MUAC) – 0.211 (Dec. tooth count)

R = 0.370; r^2= 0.137; SEE = 1.285; P<0.001

Girls age = 12.343 - 0.010 (BMI) + 0.086 (MUAC) – 0.135 (Dec. tooth count)

R = 0.257; r^2 = 0.066 SEE = 1.312; P<0.001

The residual value between the chronological age and the predicted age using the above regression equation ranges from -2.829 to 3.895 years. (Fig. 3) The marginal effects plots in figure 4 show the effect of the independent variables on the dependent variable (age). Through the present study, it was observed that around 84% of the underweight children and 90% of the obese children were not having even a single over retained deciduous tooth. At the same time, only 1.4% of the underweight children had more than 10 retained deciduous teeth in their dentition at the time of examination. (Table 5)

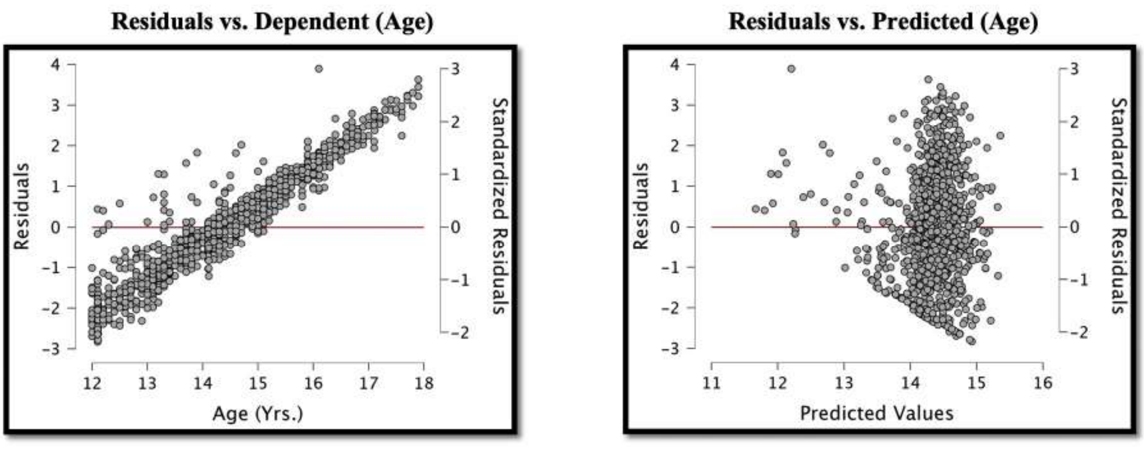

Fig. 3: Residual plots with dependent variable and the predicted variable.

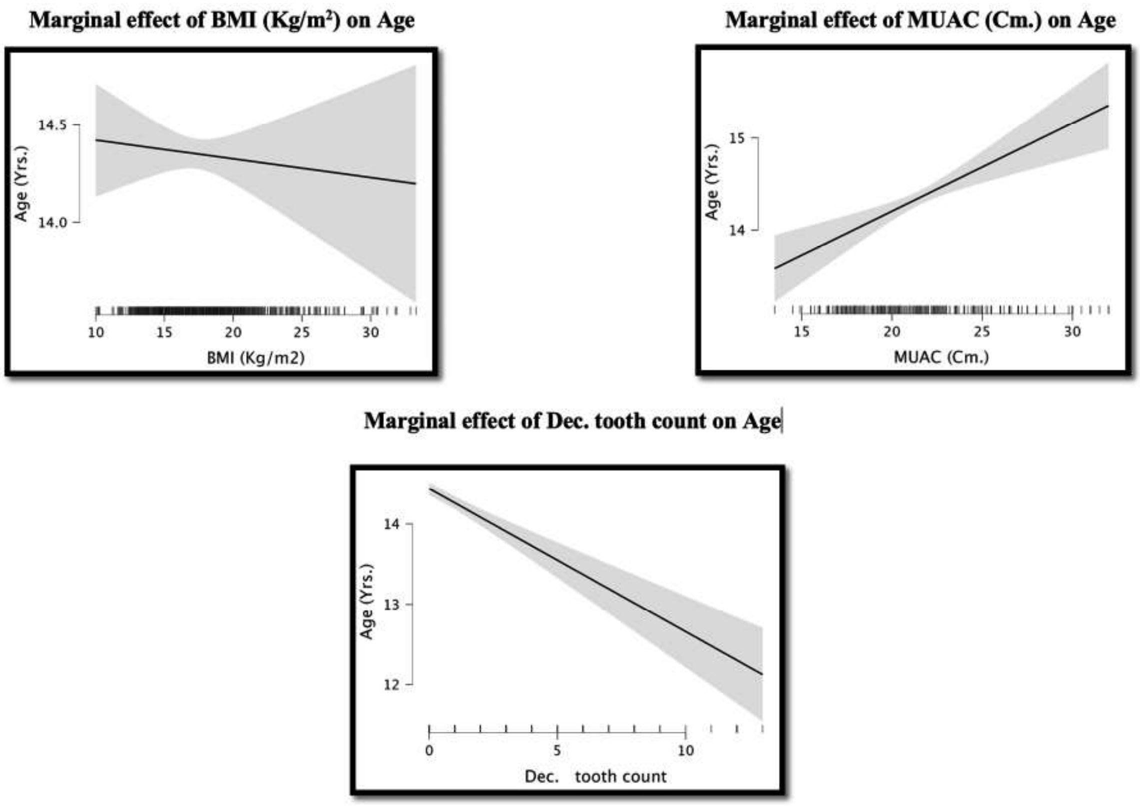

Fig. 4: Marginal effects plot of BMI, MUAC and deciduous tooth count on Age.

Table 5: Table showing the frequency distribution of the study subjects according to their BMI categories and deciduous tooth counts.

Dec. tooth count	BMI categories										X^2	df	Sig.
	<18.5 (Underweight)		18.5-24.99 (Normal)		25.0-29.99 (Over weight)		>30 (Obese)		Total				
	n	%	n	%	n	%	n	%	n	%			
Nil	654	84.3	265	91.7	27	93.1	9	90	955	86.5			
1-5 teeth	97	12.5	20	6.9	2	6.9	1	10	120	10.9			
6-10 teeth	14	1.8	4	1.4	0	0	0	0	18	1.6	13.51	9	0.141
>10 teeth	11	1.4	0	0	0	0	0	0	11	1			
Total	776	70	289	26.2	29	2.6	10	0.9	1104	100			

*Chi square test significant at p<0.05; BMI = Body Mass Index.

DISCUSSION

The ossifications in bone and the maturation stages of teeth are considered biological markers of age. The dental age estimation methods thus utilize the mineralization and the eruption status of teeth for estimating the age. It has been observed in many of these methods, the chronological age does not exactly match with the biological age and more often the population and sex based variations are most likely to occur. Hence several age estimation methods are being validated and subsequently modified based on populations. The factors like nutritional status and environmental or socioeconomic status might also contribute to variations in age estimation.[15,16] The malnourishment status in children not only affects the oral health, but also dental development.[17] In many of the age estimation methods, which rely on the development status of teeth, the nutritional status of the children is not considered. Further, some of the earlier studies have also pointed out that nutritional status has minimal or nil effect on dental development.[18,19] On the contrary, studies have shown advanced dental development or over estimation of the dental age in overweight and obese children.[20-22] The present study was conducted to explore the relationship between nutritional status and dental development using tooth count as a parameter. The study by Weddell and Hartsfield revealed an insignificant correlation between the BMI and the difference between the chronological age and the estimated age calculated using Demirjian's method.[20] A study by Hilgers et also used the orthopantomograms for estimating the age by Demirjian's method and revealed an over estimation in children with higher BMI.[21] Another radiographic study correlating the BMI with the dental development stages of Demirjian's method was conducted by Erwansyah *et al.* Their results showed that there was a strong correlation between BMI and dental age in 44.6% of the cases.[23] Similarly, a study by Anbiaee *et al*. reported that a significant correlation between BMI and dental age was present only in boys and not in girls.[24] The obese or overweight children were 3.5 times more dentally advanced.[25] As the data in the present study was obtained from a large number of school children during screening in their respective schools, the radiographs were not taken and thus the mineralization of teeth was not used as a parameter for dental development. The nutritional status of children and their BMI also influence the eruption or clinical emergence of teeth.[26] The skeletal dental maturity is accelerated when compared to the chronological age from normal weight to obese children. According to a study, the difference between chronological and skeletal dental age is statistically significant for pre-obese ($p=0.01$) and obese ($p<0.001$) children, while it is not significant for underweight ($p=0.46$) and normal weight ($p=0.33$) children.[27] But in the present study, the BMI was directly correlated with the chronological age and the deciduous tooth count in children. The result revealed a significant difference in the tooth count among the children of different BMI categories. The tooth count method may be considered a simple and economical way of estimating the age especially when the focus of the research community is on the application of advanced tools like CT and CBCT.[28,29] The advantages of using the tooth count method were highlighted by Hagg and Taranger.[30] Quantifying the deciduous and permanent teeth in the oral cavity for age estimation in malnourished children was also earlier attempted by Psoter *et al*.[31] Their study revealed that malnourishment in early childhood may affect the exfoliation of deciduous teeth. The study subjects in their study were in the age range of 11-13 years. The present study quantified the deciduous teeth in the age group when it is less likely to be observed in the oral cavity and correlated with the BMI of the children. As the age increases from 12 years, the probability of the presence of deciduous teeth decreases. Nearly 86% of the children in this age group under study were not having even a single deciduous tooth. More number of underweight category children (15.7%) were having deciduous teeth in their oral cavity when compared to the other categories. However, the association was not statistically significant ($X^2=13.51$, $df=9$, $p>0.05$). The BMI value was also compared clinically with the permanent tooth count in another Brazilian study conducted in children in the age range of 9 to 12 years. The study reported that the mean number of permanent teeth was significantly higher in the overweight/obesity group.[32] An Indian study on 100 children in the age range of 10-18 years has shown an inconsistent association between dental age and BMI.[33] A study by Kutesa *et al* revealed an insignificant influence of height and a non-conclusive influence of weight on tooth eruption in children in Uganda.[34] But the present study did not attempt to correlate the anthropometric data independently with the age. The present study also used the MUAC values as an indicator of malnourishment in children.

CONCLUSION

The present study was an attempt to evaluate the effect of the nutritional status of children in the age group of 12 to 18 years on tooth count. Within the limitations of the study, it may be concluded that there was no significant association between BMI and deciduous tooth count. It is highly recommended that huge sample studies from different populations need to be designed to test the association between BMI and tooth development.

REFERENCES

1. ***Melsen B, Wenzel A, Miletic T, Andreasen J, Vagn-Hansen PL, et al. (1986)*** *Dental and skeletal maturity in adoptive children: assessments at arrival and after one year in the admitting country. Ann Hum Biol 13: 153–159.*
2. ***Holman DJ, Jones RE.*** *Longitudinal analysis of deciduous tooth emergence: IV. Covariate effects in Japanese children. Am J Phys Anthropol 2005;126:352-8*
3. ***Bastos JL, Peres MA, Peres KG, Barros AJ.*** *Infant growth, development and tooth emergence patterns: A longitudinal study from birth to 6 years of age. Arch Oral Biol 2007;52:598-606.*
4. ***Bagherpour A, Pousti M, Adelianfar E.*** *Hand skeletal maturity and its correlation with mandibular dental development. J Clin Exp Dent. 2014 Jul 1;6(3):e275-9.*
5. ***Rebouças PRM, Alencar CRB, Arruda MJALLA, Lacerda RHW, Melo DP, Bernardino IM, Bento PM.*** *Identification of dental calcification stages as a predictor of skeletal development phase. Dental Press J Orthod. 2021; 26(4):e2119292.*
6. ***Soliman NL, El-Zainy MA, Hassan RM, Aly RM.*** *Relationship of deciduous teeth emergence with physical growth. Indian J Dent Res. 2012 Mar-Apr;23(2):236-40. doi: 10.4103/0970-9290.100433.*
7. *Nuttall FQ. Body mass index: Obesity, BMI, and health: a critical review. Nutr Today. (2015) 50:117–28.*
8. ***Mwangome M, Ngari M, Fegan G, Mturi N, Shebe M, Bauni E, et al.*** *Diagnostic criteria for severe acute malnutrition among infants aged under 6 mo. Am J Clin Nutr. 2017;105(6):1415–23.*
9. ***Oziegbe EO, Adekoya-Sofowora C, Folayan MO, Esan TA, Owotade FJ.*** *Relationship between socio-demographic and anthropometric variables and number of erupted primary teeth in suburban Nigerian children. Matern Child Nutr 2009;5:86-92.*
10. ***Cummaudo M, De Angelis D, Magli F, Minà G, Merelli V, Cattaneo C.*** *Age estimation in the living: A scoping review of population data for skeletal and dental methods. Forensic Sci Int. 2021;320:110689.*
11. ***Parhiz, S. H., Zamanzadeh, M., Ahmadi, M., Arabi, M., & Zamanfar, D. (2019).*** *The Relationship between Body Mass Index and Dental Development in 5 to 6 Years Old Children in Sari. International Journal of Medical Investigation, 8(3), 29-39.*
12. ***Bidira, K., Tamiru, D. & Belachew,*** *T. Effect of nutritional education on anthropometric deficits among pre-school aged children in south West Ethiopia: quasi-experimental study. Ital J Pediatr 48, 8 (2022).*
13. ***Benítez Brito N, Suárez Llanos JP,Fuentes Ferrer M, et al.*** *Relationship between Mid-Upper Arm Circumference and Body Mass Index in Inpatients. PLoS One. 2016;11 (8):e0160480. Published 2016 Aug 5. doi:10.1371/journal.pone.0160480*
14. ***World Health Organization, WHO.*** *Oral Health Surveys: Basic methods, 5th Ed. 2013.*
15. ***Saleemi MA, Hägg U, Jalil F, Zaman S.*** *Timing of emergence of individual primary teeth. A prospective longitudinal study of Pakistani children. Swed Dent J. 1994;18:107–12.*
16. ***Holman DJ, Yamaguchi K.*** *Longitudinal analysis of deciduous tooth emergence: IV. Covariate effects in Japanese Children. Am J Phys Anthropol. 2005;126:352–8.*
17. ***Rahman N, Walls A.*** *Chapter 12: Nutrient Deficiencies and Oral Health. Monogr Oral Sci. 2020;28:114-124. doi: 10.1159/000455379. Epub 2019 Nov 7. PMID: 31940618.*
18. ***Mani SA, Naing L, John J, Samsudin AR.*** *Comparison of two methods of dental age estimation in 7–15-year-old Malays. Int J Paediatr Dent. 2008; 18:380–8.*
19. ***Elamin F, Liversidge HM.*** *Malnutrition has no effect on the timing of human tooth formation. PLoS One. 2013 Aug 30;8(8):e72274.*
20. ***Weddell LS, Hartsfield Jr JK.*** *Dental maturity of Caucasian children in the Indianapolis area. Pediatric dentistry. 2011 Jun 15;33(3):221-7.*
21. ***Hilgers KK, Akridge M, Scheetz JP, Kinane DE.*** *Childhood obesity and dental development. Pediatr Dent. 2006; 28:18–22.*
22. ***Omar S, Oyoyo U, Alfi W, Espinoza R, Jang P, Lee WJ.*** *Relationship Between Body Mass Index and Dental Development in a Contemporary Pediatric Population in the United States. J Dent Child (Chic). 2019 May 15;86(2):93-100.*
23. ***Erwansyah E, Susilowati, Akbar FH, Rustam A.*** *Relationship between body mass index and dental age in 8-15-year-old orthodontic patients. Pesqui Bras Odontopediatria ClínIntegr. 2020; 20:e 4775.*
24. ***Anbiaee, N., Rashed Mohassel, A., Bagherpour, A.*** *The Relationship between Body Mass Index and Dental Development by Demirjian's Method in 4- to 15-Year-Old Children in Mashhad. Journal of Dental Materials and Techniques, 2013; 2(3): 82-85.*
25. ***Chehab DA, Tanbonliong T, Peyser J, Udin R.*** *Association between body mass index and dental age in Hispanic children. Gen Dent. 2017 Jul 1;65(4):54-8.*
26. ***Šindelářová R, Soukup P, Broukal Z.*** *The relationship of obesity to the timing of permanent tooth emergence in Czech children. Acta Odontol Scand. 2018 Apr; 76(3):220-225.*
27. ***Costacurta M, Sicuro L, Di Renzo L, Condò R, De Lorenzo A, Docimo R.*** *Childhood obesity and skeletal-dental maturity. Eur J Paediatr Dent. 2012 Jun;13(2):128-32.*
28. ***Merdietio Boedi R, Shepherd S, Mânica S, Franco A.*** *CBCT in dental age estimation: A systematic review and meta analysis. Dentomaxillofac Radiol. 2022 Jan 7:20210335. doi: 10.1259/dmfr.20210335. Epub ahead of print.*
29. ***Asif MK, Nambiar P, Mani SA, Ibrahim NB, Khan IM, Lokman NB.*** *Dental age estimation in Malaysian adults based on volumetric analysis of pulp/ tooth ratio using CBCT data. Leg Med (Tokyo). 2019 Feb;36:50-58. doi: 10.1016/j. legalmed.2018.10.005. Epub 2018 Oct 21.*
30. ***Hägg U, Taranger J.*** *Dental development, dental age and tooth counts. Angle Orthod. 1985 Apr;55(2):93-107.*
31. ***Psoter W, Gebrian B, Prophete S, Reid B, Katz R.*** *Effect of early childhood malnutrition on tooth eruption in Haitian adolescents. Community Dent Oral Epidemiol. 2008 Apr;36(2):179-89.*
32. ***Evangelista SES, Vasconcelos KRF, Xavier TA, Oliveira S, Dutra ALT, Nelson-Filho P, Silva LABD, Segato RAB, Queiroz AM, Küchler EC.*** *Timing of Permanent Tooth Emergence is Associated with Overweight/Obesity in Children from the Amazon Region. Braz Dent J. 2018 Sep-Oct;29(5):465-468. doi: 10.1590/0103-6440201802230.*

33. ***Panchbhai A, Vasistha A, Hande A.*** *Evaluation of the association of dental development with chronological age and body mass index in children visiting rural hospital. J Datta Meghe Inst Med Sci Univ 2020;15:565-72.*

34. ***Kutesa A, Nkamba EM, Muwazi L, Buwembo W, Rwenyonyi CM.*** *Weight, height and eruption times of permanent teeth of children aged 4-15 years in Kampala, Uganda. BMC Oral Health. 2013 Mar 16;13:15.*

REVIEW ARTICLE

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Review on Facial Changes Across Age Progression of the same Individual and its Application in Forensics

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ABSTRACT

Introduction: It is difficult to describe or analyze face aging since it is a complex process driven by both intrinsic and extrinsic factors. Face aging differently influencesthe facial components of an individual such as the nose, mouth, and eyes.

Objective: In this paper, we have discussed reviewing facial features, that change with the progression of age and techniques available to recognize these changes.

Method: The majority of the work on face recognition has been carried out on adults and less of the work is reported on facial aging. Researchers have tried to develop algorithms for facial recognition, verification, and identification system which will have low false positive rates and high true positive rates due to the age influencing factor.

Conclusion: It will help the scientific community for better analysis and recognition.

Keywords: Facial features; Non-adult; and adult age facial features; Age progression; Factors affecting age; Facial recognition; Verification; Identification; Age estimation; Age simulation.

INTRODUCTION

"You can never see the same face twice" The assertion is not ironic. Science approved this line because facial appearance changes frequently or dynamically due to facial expression, pose, illumination, the profile of the head, aging, occlusion, moustaches, beards, cosmetics, and hairstyle, so these factors create problems in face recognition, face identification and face verification.[1,2] Aging is an inevitable and uncontrollable process. It is a slow and irreversible process. The achieved aging pattern is temporal since these temporary alterations in facial look at a certain period affect an individual's future appearance but not their past appearance. The human face is the man's identity card, and it is individual for everyone like fingerprint biometrics, iris biometrics, etc. even twins have some individuality in his/her face.[3] It has been observed that appearance of the face changes with the

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progression of age. It creates difficulty in automatic face recognition, verification and identification system. So, in this paper, an attempt has been made to mitigate the aging issue in face recognition, and also to analyse and estimate the age of individuals by studying the facial features or landmarks and for face remodelling.

AGE RELATED CHANGES IN FACE

Individuals have different aging patterns, although there may be variations or similarities which can be modelled. Even different races have different aging pattern.[4] Complexities of facial aging have been studied by studying various landmarks in faces.[5] In different age groups, facial changes happen differently. There are two distinct stages of facial growth in human life: the formative stage and the aging stage. In childhood (generally up to 20 years of age) mainly craniofacial changes occur and with advances in age mainly skin texture or morphological changes occur and minimal bony structure changes. But in senescence, bony structure changes in the maxilla due to bone resorption.[6,7] Certain hard and soft tissue changes with age that help to change the shape, size, and appearance of a person. It is also found that age related changes, especially the development of wrinkles, differ between gender. And there are individual features of every individual that affect the speed of aging differently.[8] To analyse, the morphological changes with the advancement of age, the face is divided into three-part that is the upper 1/3 (which covers the forehead and brows region), the middle 1/3 (which covers the midface and nose region), and the lower 1/3 (which covers chin, jawline, and neck region). Age related changes in adolescence are different from changes seen in adults.

Stages of facial changes in Children (Children from birth to childhood, up to 16 years)

This stage is called the formative stage which means the growth and development phase. More rapid facial changes occur during childhood. In the development phase mainly significant facial shape changes happen due to craniofacial enlargement.[2] In this phase, the forehead of the individual slopes back that helps to create space on the skull to hold the growing brain. The nose, mouth, eyes, and ears expand with the growth of an individual to cover interstitial space. The chin curves more as the cheeks expand. Facial skin remains relatively unchanged than shape. So, a circular shape face changes into an oval shape face as age increases in the younger age group due to craniofacial growth. As a result position of fiducial landmarks changes. This phenomenon helps to estimate age in the younger age group.[9]

Stages of facial changes in Adult/aging stage:

In adult age, craniofacial changes occur at the soft tissue level as well as at the hard tissue level. Hard tissue changes in adolescence and adulthood are due to skeletal growth and development, whereas bone re-modeling and resorption is the main factor in changes in hard tissue level in young adulthood to senescence. While in the case of soft tissue, begin to show aging phenomena, at the age of ’20s or as early as 20s. but the aging of soft tissue is most noticeable in the ’40s to ’50s and becomes more pronounced at the age of 50s to ’60s.[10]

Bony changes:

The dimensions of the cranium change in the vertical, horizontal and sagittal planes, as well as in the dentoalveolar area. Many of these modifications, however, are minor, ranging from 1.1mm to 1.60mm.[10] Increases in total head size, head length (from front to back), bizygomatic breadth (from cheekbone to cheekbone), and head width are all examples of horizontal alterations. These horizontal changes occur from the ’20s to the ’80s. Vertical changes occur in an increase of anterior face height. And this increase in height is more noticeable in the bottom half of the face than in the top half. Total face height of an individual increase by about 1.60mm where the upper face increases by about 1/5 and the lower face increase about 4/5.[21] Sagittal changes occur in a slight increase in the thickness of the cranium anterior-posteriorly. With age progression, the anterior facial skeleton displays greater convexity. The mostly dentoalveolar region is changed throughout the adult age progression.[10]

Soft tissue changes

Adult face changes more with relatively large skin texture variations and minimal variation in shape.[2] According to johan wisth, 2007, alterations in the soft tissue profile of children aged 4 to 10 years were evaluated. They have found that in this age group mainly alterations are in the soft tissue profile with that of change in skeletal profile. And in this age group mostlyface convexity changes due to nose growth. Bishara, S.E. *et al* 1998 studied what alterations occur to soft tissue profilein people aged 5 to 45 years. They found that generally the direction and magnitude of face changes in both sexes were almost similar. But females show greater soft tissue changes earlier (within the age range of 10 to 15 years) than males (within the age range of 15 to 25 years). Soft tissue convexity angle excluding nose showed small changes between the ages of 5 and 45 years. Wysong A *et al* (2013) quantified and compared the loosening of facial soft tissue with age progression using used magnetic resonance imaging (MRI) technique. They discovered that between the ages of 30 and 60, the most significant alterations occur in the temporal, infraorbital, and lateral and medial cheek regions.[11] Adult facial soft tissue changes are best studied by splitting the face into three sections: top third, middle third, and bottom third.

Upper third

Because of loosing of skin elasticity, the impact of gravity, and recurrent periorbital muscular contractions, drooping of eyebrows appears. Upper eyelid skin folds due to decreasing skin elasticity of the skin and excess unsupported skin. The aging of the periorbital region differs among individuals, even of different sex and race. European, Indian, and Chinese have also the difference in eyebrows and eyelids features.[12,13] Kunjur *et al.*, 2006 studied facial features from photographs of these three ethnic groups: European, Indian and Chinese resulting that eyebrows of Indian and Chinese males are significantly different, but upper eyelids are significantly different between all three ethnic group and in both males and females. Palpebral fissure length was significantly different between Indian and European males and Indian male has wider palpebral fissure.

Middle third

Nasolabial fold develops due to weakening of malar fat pad. At the age of 20-30 years the nasolabial lines start to form and at the age of 40-50 years the folds increase in depth and at the age of beyond 60 years the folds further continues to be deepen. With the progression of age, Nose shifts forward and downward.

Lower third

Mainly in the 40s of individuals' life span, vertical rhytids appear above the vermilion border and ornamental grooves appear at the corners of lips as the skin thins with age. And the depth of these phenomena increases as age progress. In the 50s of an individual's life span, Buccomandibular crease, jowls, along with sagging chin appears and it appears more noticeably in the 60s of an individual's life span and beyond 60. Elongation of the lip happens and it appears to be thinner as age progress and many other additional lip related changes occur with age progression.[10]

How bony and soft tissue changes occur in different age groups is listed bellow in form of table bellow.[13-15]

Table 1: Skeltal and tissue changes observed in different age groups

Age range	Probable Skeletal changes	Probable Soft tissue changes
Childhood-Adolescence	• In this stage face shape changes due to craniofacial growth • Forehead slopes back • Circular shape face changes into oval shape face as age increases in this age group • Maximum Cranial breadth is relatively large • Upper and lower facial height increase • The upper and lower incisors protrude significantly • Eyes, ears, mouth, and nose expand • Cheeks extend and chin protrudes • The rapid expansion of the eyes in the 1st year of life causes the orbits to be bigger than the rest of the face • Maxillary dentoalveolar measurements change significantly • Prognathism of maxilla and mandible	• Facial skin moderately remain unchanged
Early adolescence – early adulthood	• The upper and lower jaw relatively stable inclination	• In comparison to the growth of soft tissue in the chin and glabella. The nose grows further forward

Table to be cont....

	• In respect to the maxillary and mandibular planes, the upper and lower incisors show retrusions	• Upper eyelid starts to droop
	• Because teeth continue to emerge, the lower anterior and posterior facial heights rise	• Eyes look smaller
	• Downward growth of mandible	• Formation of Nasolabial lines begins
		• Formation of lateral orbital lines begins
		• The Upper lid starts to retrude in females.
Early adulthood - Mid adulthood (about 47)	• Sella-nasion length increase significantly	• Length of upper lip increase (~3.2 mm)
	• Midfacial length increase significantly	• Upper lip thinning (~ 3.6 mm), upper lip flattening
	• Forward movement of maxilla	• At the pogonion point soft tissue thickness increase
	• Significant increase of mandibular length	• Columella and pronasale vertical increase. Results movement of nose downward and forward
	• Upper facial height increase significantly. Even lower facial height increases. As a result total facial height increase	• Forward growth of chin also
	• Age-related bone remodeling	• With age, the upper lip thins and the soft tissue at the chin and glabella thickens, resulting in a straighter facial profile
	• Gonial angle increase	• The formation of cireumoral striae begins. Lines begin to appear from the lateral borders of the nose to the lateral edges of the lips
	• The incisors continue to erupt although non-significantly	
	• Significant retrusion and retroclination can be seen on both the upper and lower incisors	
	• Retrognathism of maxilla and mandible due to bone remodelling	
	• Maxillary dentoalveolar measurements changes but not statistically significant	
Mid adulthood - Late adulthood (about 57)	• No change in the sella-nasion length	• Upper lip length increase continue (1.4 mm)
	• Increase in midfacial length but not significant	• Thinning of upper lip continue (1.4 mm)
	• Minimal increase of the anterior face height which is mainly lower anterior face height	• Dermis level Changes: in this age group epidermis becomes thin/lean and subcutaneous fat loss happens
	• Forward movement of maxilla consistent	• At the pogonion point, soft tissue thickness increases
	• Small increases in mandibular length	• Columella and pronasale vertical continue to increase. But significantly columella move inferiorly. And this movement of columella downwards results significant decrease in nasolabial angle.
	• Age-related bone remodeling	• Upper and lower lips continue to shift downwards which exceeded the skeletal downward growth, result les-prominent display of the upper incisor
	• Gonial angle increase	• Facial lines and folds increase continuously in depth
	• Bone remodelling	• Due to alveolar bone remodeling Concave appearance appears in cheek hollows
	• Alveolar bone remodelling	
	• Dental attrition affecting vertical facial height	
	• Alveolar bone remodel	

FACTORS AFFECTING FACIAL AGING

Hard tissue changes in the head and face may not necessarily result in predictable patterns of change in the head and face's overlaying muscles and skin. This is a significant obstacle in facial reconstruction procedures and in developing effective age progression techniques. This is because there are many intrinsic and extrinsic factors that affect the pattern of facial aging.[8] Skin on face ages in two ways, internally and externally. Human experience internal or natural aging as they gets older.

Causes of internal aging and their effect on facial appearance are listed below table:

Table 2: Causes of Internal aging and its effect in facial aging process.

Cause	Effect
Slow down of collagen production	Loss of skin firmness
Decreases in Elastin production	Loss of skin elasticity
Beginning Disappearance of fat cells	Sagging of skin
Loss of ability to retain moisture	Skin looks dull, skin tone and complexion appear uneven, and fine lines and wrinkles are more noticeable.
Muscle contraction	Frown lines, wrinkles, folds, etc. appear
As dead skin cells sheds quickly.	Flaky skin, dry patches, and clogged pores
Slightly less turnover of new skin cells (skin cell turnover or skin cell rejuvenation)	Visible sign of aging, wrinkles, age or liver spots, hyperpigmentation. Visible blemishes, acne development, whiteheads, blackheads

Many factors can influence natural face aging by delaying the process. Forces responsible for facial aging is gravity, soft tissue maturation, loss of subcutaneous fat, hormonal imbalance, mental stress, diet, work practice, drug abuse, and disease, skeletal remodeling, teeth loss, muscular facial activity, environment, orthodontic treatment, gender and solar changes or UV light. environmental and genetic factor also influence face aging patterns so much. Some of the factors of facial aging is uncontrollable as they are hereditary but many of the factors are controllable which is most of the time harmful habits like smoking. Due to factor of different facial anatomy, difference of hormones and different lifestyle etc. between male and female, shows different aging pattern.[16] It has been observed that female shows greater and faster changes than male after menopause due to hormonal changes.

APPLICATION OF FACIAL AGING STUDY IN THE CONTEXT OF FORENSIC PERSPECTIVE

Personal identification of the human in the context of forensic science is important in natural and man-made mass disasters. To establish identity of individual, skull play very important role, as face can be reconstructed by skull.[17] In that case to reconstruct skull, data of age related features is needed to give perfect appearance as much as possible. Not only in the case of post mortem identification of individual, but also in case of antemortem identification of individual face play important role for person recognition, verification and identification. And for this purpose many face recognition application has also been developed. But in the time of facial recognition, verification and identification, facial changes across age progression, may create hindrance. So, to mitigate this problem various age invariant face recognition system has been developed. And to develop this type of age invariant face recognition application, data related to facial aging is required.

Here are some importance of studying age related changes.

- ***Facial reconstruction or facial image reconstruction:*** Pan SY *et al* 2018 has studied age related changes of xinjiang uygur male facial images to construct an age estimation model and to construct individual face images of old age and young age. Their main findings is the nasolabial sulcus deepening, cheek sinking, cheek bone protruding, and eye corner drooping with age.[18] Facial shape and surface features has been combined into image reconstruction of facial appearance.[19]
- ***Age invariant facial recognition:*** Face recognition is a very sophisticated biometric tool for human identification. For that, several face recognition methods available. In the below table different facial recognition method has been listed.[20]

Table 3: Different facial recognition methods and their comparison.

Method	Working principle	Examples
Holistic matching methods	Complete face region is taken into account as input data	Eigenfaces
		Principal Component Analysis (PCA)[21]
		Linear Discriminant Analysis (LDA)[21]
		Independent component analysis
Feature based (Structural) method	Local components like eyes, nose and mouth extracted at first and their locations and local statistics (geometric and/or appearance) are put into a structural classifier	Active shape model (ASM)[22]
		Low level analysis[22]
		Feature analysis[22]
Hybrid methods	Use a combination of both holistic and feature extraction methods[23, 24]	

Data of facial aging features help to develop a good quality (high true positive rated and low false positive rated) age invariant facial recognition (AIFR) system.[25] Age invariant Face recognition system help to find lost children.[26] AFIR can be divided into generative[27-29] and non-generative methods.[30-32] Recently, deep neural network method has been used.[33-36]

Face age synthesis

- ***Age Estimation:*** in this technique age is estimated from given face image.[37,38]
- ***Age separated face recognition:*** a person's face is recognized using age separated photographs.[39]
- Homeland security and law enforcement.[40]
- Face recognition is utilized in forensic investigation like to investigate de-duplication of driver's license, identifying missing children.[41]
- ***Access control and monitoring systems:*** The age estimation system provides access control for various internet of things across different age groups. Like it can protect non-adult communities from adult and illegitimate web content.
- ***Age simulation:*** it is the technique of modelling the facial appearance across age progression.[42,2]

CONCLUSION

Child aging is more complex than adult aging due to the structural change as well as in the shape and size of the facial components. The overlaying muscles and skin of the head and face don't always follow predictable patterns of changes in the hard tissue of the head and face. This is a significant obstacle in efforts to reconstruction of face and to develop an efficient age progression techniques. It has been observed that the nose appears to be the most constant component of the face as it ages, and that females are more affected by ageing than males. There are many automatic face recognition system available which will help to recognize face. Somewhere they adders aging factors also but in real situation, images recovered for facial recognition and verification with age progression or recovered for age estimation, is of low quality. In that case present algorithms are hardly able to detect facial aging features. So in that case there need more research on face image so that if software are unable to detect these facial aging features, some manual method can be used.

REFERENCES

1. ***Anwarul S, Dahiya S.*** *A comprehensive review on face recognition methods and factors affecting facial recognition accuracy. Proceedings of ICRIC 2019. 2020;495-514.*
2. ***Angulu R, Tapamo JR, Adewumi AO.*** *Age estimation via face images: a survey. EURASIP Journal on Image and Video Processing. 2018;2018(1):1-35.*
3. ***Paone JR, Flynn PJ, Philips PJ, Bowyer KW, Bruegge RW, Grother PJ, Quinn GW, Pruitt MT, Grant JM. Double trouble:*** *Differentiating identical twins by face recognition. IEEE Transactions on Information forensics and Security. 2014;9(2):285-95.*
4. ***Vashi NA, Maymone MB, Kundu RV.*** *Aging differences in ethnic skin. The Journal of clinical and aesthetic dermatology. 2016 ;9(1):31.*
5. ***Verma R, Bhardwaj N, Bhavsar A, Krishan K.*** *Towards facial recognition using likelihood ratio approach to facial landmark indices from images. Forensic Science International: Reports. 2022; 5:100254.*
6. ***Fu Y, Guo G, Huang TS.*** *Age synthesis and estimation via faces: A survey. IEEE transactions on pattern analysis and machine intelligence. 2010; 32(11):1955-76.*

7. ***Park U, Tong Y, Jain AK.*** *Age-invariant face recognition. IEEE transactions on pattern analysis and machine intelligence. 2010;32(5):947-54.*

8. ***Sveikata K, Balciuniene I, Tutkuviene J.*** *Factors influencing face aging. Literature review. Stomatologija. 2011;13(4):113-6.*

9. ***Dehshibi MM, Bastanfard A.*** *A new algorithm for age recognition from facial images. Signal Processing. 2010;90(8):2431-44.*

10. ***Albert M, Sethuram A, Ricanek K.*** *Implications of adult facial aging on biometrics. Biometrics-Unique and Diverse Applications in Nature, Science, and Technology. 2011; 4:89-106.*

11. ***Wysong A, Joseph T, Kim D, Tang JY, Gladstone HB.*** *Quantifying soft tissue loss in facial aging: a study in women using magnetic resonance imaging. Dermatologic Surgery. 2013;39(12):1895-902.*

12. ***Sharma P, Arora A, Valiathan A.*** *Age changes of jaws and soft tissue profile. The Scientific World Journal. 2014; 2014:1-7.*

13. ***Kaur M, Garg RK, Singla S.*** *Analysis of facial soft tissue changes with aging and their effects on facial morphology: A forensic perspective. Egyptian Journal of Forensic Sciences. 2015;5(2):46-56.*

14. ***Costello BJ, Rivera RD, Shand J, Mooney M.*** *Growth and development considerations for craniomaxillofacial surgery. Oral and Maxillofacial Surgery Clinics. 2012;24(3):377-96.*

15. ***Buschang PH, Jacob HB, Demirjian A.*** *Female adolescent craniofacial growth spurts: real or fiction?. European journal of orthodontics. 2013 Dec 1;35(6):819-25.*

16. ***Keaney TC.*** *Aging in the male face: intrinsic and extrinsic factors. Dermatologic Surgery. 2016 1;42(7):797-803.*

17. ***Kanchan T, Krishan K.*** *Personal identification in forensic examinations. Anthropol. 2013;2(1):114.*

18. ***Pan SY, Chen ST, Tang K, Li CX, Liu J, Ye J, Zhao WT.*** *Age Estimation and Age-related Facial Reconstruction of Xinjiang Uygur Males by Three-dimensional Human Facial Images. Fa yi xue za zhi. 2018 ;34(4):363-9.*

19. ***Chang CH, Nemrodov D, Drobotenko N, Sorkhou M, Nestor A, Lee AC.*** *Image reconstruction reveals the impact of aging on face perception. Journal of Experimental Psychology: Human Perception and Performance. 2021; 47(7):977-991.*

20. ***Jayaraman U, Gupta P, Gupta S, Arora G, Tiwari K.*** *Recent development in face recognition. Neurocomputing. 2020 Sep 30;408:231-45.*

21. ***Satonkar Suhas S, Kurhe Ajay B, Prakash Khanale B.*** *Face recognition using principal component analysis and linear discriminant analysis on holistic approach in facial images database. Int Organ Sci Res. 2012;2(12):15-23.*

22. ***Hatem H, Beiji Z, Majeed R.*** *A survey of feature base methods for human face detection. International Journal of Control and Automation. 2015;8(5):61-78.*

23. ***Sing JK, Chowdhury S, Basu DK, Nasipuri M.*** *An improved hybrid approach to face recognition by fusing local and global discriminant features. International Journal of Biometrics. 2012 Jan 1;4(2):144-64.*

24. ***Verma M, Rani P, Kundra H.*** *A hybrid approach to human face detection. International Journal of Computer Applications. 2010 Feb;1(13):67-9.*

25. ***Sawant MM, Bhurchandi KM.*** *Age invariant face recognition: a survey on facial aging databases, techniques and effect of aging. Artificial Intelligence Review. 2019 Aug;52(2):981-1008.*

26. ***Deb D, Nain N, Jain AK.*** *Longitudinal study of child face recognition. In 2018 International Conference on Biometrics (ICB) 2018; 20; 225-232.*

27. ***Du JX, Zhai CM, Ye YQ.*** *Face aging simulation and recognition based on NMF algorithm with sparseness constraints. Neurocomputing. 2013 Sep 20;116:250-9.*

28. ***Park U, Tong Y, Jain AK.*** *Age-invariant face recognition. IEEE transactions on pattern analysis and machine intelligence. 2010 Jan 15;32(5):947-54.*

29. ***Pan Z, Wang Y, Zhang S.*** *Joint face detection and Facial Landmark Localization using graph match and pseudo label. Signal Processing: Image Communication. 2022 Mar 1;102:116587.*

30. ***Ling H, Soatto S, Ramanathan N, Jacobs DW.*** *Face verification across age progression using discriminative methods. IEEE Transactions on Information Forensics and security. 2009 Dec 15;5(1):82-91.*

31. ***Li Z, Park U, Jain AK.*** *A discriminative model for age invariant face recognition. IEEE transactions on information forensics and security. 2011 May 19;6(3):1028-37.*

32. ***Otto C, Han H, Jain A.*** *How does aging affect facial components?. In European conference on computer vision 2012 Oct 7 (pp. 189-198). Springer, Berlin, Heidelberg.*

33. ***Xu C, Liu Q, Ye M.*** *Age invariant face recognition and retrieval by coupled auto-encoder networks. Neurocomputing. 2017;222:62-71.*

34. ***Sajid M, Shafique T, Manzoor S, Iqbal F, Talal H, Samad Qureshi U, Riaz I.*** *Demographic-assisted age-invariant face recognition and retrieval. Symmetry. 2018 May 7;10(5):148.*

35. ***Zheng T, Deng W, Hu J.*** *Age estimation guided convolutional neural network for age-invariant face recognition. In Proceedings of the IEEE conference on computer vision and pattern recognition workshops 2017 (pp. 1-9).*

36. ***Li Y, Wang G, Nie L, Wang Q, Tan W.*** *Distance metric optimization driven convolutional neural network for age invariant face recognition. Pattern Recognition. 2018 1;75:51-62.*

37. ***Liao H, Yan Y, Dai W, Fan P.*** *Age estimation of face images based on CNN and divide-and-rule strategy. Mathematical Problems in Engineering. 2018;2018: 1-8.*

38. ***Liu H, Lu J, Feng J, Zhou J.*** *Group-aware deep feature learning for facial age estimation. Pattern Recognition. 2017;66:82-94.*

39. ***Yadav D, Singh R, Vatsa M, Noore A.*** *Recognizing age-separated face images: Humans and machines. PloS one. 2014 4;9(12):e112234.*

40. ***Sawant MM, Bhurchandi KM.*** *Age invariant face recognition: a survey on facial aging databases, techniques and effect of aging. Artificial Intelligence Review. 2019;52(2):981-1008.*

41. ***Sharif M, Naz F, Yasmin M, Shahid MA, Rehman A.*** *Face Recognition: A Survey. Journal of Engineering Science & Technology Review. 2017; 1(2);10.*

42. ***Du JX, Zhai CM, Ye YQ.*** *Face aging simulation and recognition based on NMF algorithm with sparseness constraints. Neurocomputing. 2013 Sep 20;116:250-9.*

CASE REPORT

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Dead Lifts and Death: Sudden Death due to Hypertrophic Cardiomyopathy in a Body Builder

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ABSTRACT

Background: It is a well established fact that cardiac health and exercise go hand in hand. However, rigorous exercising regimens without proper cardiovascular screening can lead to catastrophic death in unsuspecting and otherwise healthy individuals. Among the underlying undetected cardiovascular conditions that need to be accounted for, especially in young adults, are hypertrophic cardiomyopathies.

Case details: The deceased, a 33-year-old state level bodybuilder, was participating in a body building competition when he suddenly complained of dizziness and collapsed. The deceased appeared to have no significant findings on external examination. Internal examination, however, revealed that the heart was enlarged and weighed 698 g. On microscopic examination, ventricle sections showed enlarged myocytes with disarray and enlarged nuclei. The cause of death was ascertained to be due to complications of hypertrophic cardiomyopathy.

Implications for clinical practice: Among the feasible options available in low and middle income countries, electrocardiography is an inexpensive method as a screening test, leading the way for using tools such as CMR, serum biomarkers and genetic testing if required.

Conclusion: Understanding the relationship between physical exertion and its effect on a hypertrophic heart is essential. The case presented brings to light the need for in-depth pre-competition screening of athletes. This is especially true since athletes are the one category of individuals where good health is taken for granted.

Keywords: Hypertrophic cardiomyopathy; Bodybuilder; Sudden cardiac death.

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INTRODUCTION

It is a well established fact that cardiac health and exercise go hand in hand. A sedentary lifestyle is a major contributing factor to declining cardiovascular health, amongst other risk factors. This inactivity leads to the development and progression of cardiovascular disease. More importantly, regular exercise reduces blood pressure, increases insulin sensitivity, and produces a more favourable plasma lipoprotein profile.[1] Physically active individuals may have a modest increase in life expectancy and a decreased risk of all cause mortality, which is effectively linked to decreased susceptibility to developing cardiovascular and respiratory diseases.[2] However, rigorous exercising regimens without proper cardiovascular screening can lead to catastrophic death in unsuspecting and otherwise healthy individuals.

Among the underlying undetected cardiovascular conditions that need to be accounted for, especially in young adults, are hypertrophic cardiomyopathies. According to the cohort study Cardia (Coronary Artery Risk Development in Young Adults) conducted using standard echocardiography, hypertrophic cardiomyopathy was prevalent in every 1 in 500 persons.[3] However, a recent U.S. study claims the prevalence is about 1:30,000 (0.03%).[4] Previously, the autosomal dominant transmission of HCM was not accounted for, bringing the prevalence to 1:200 (0.5%) or even greater.[5]

Here is a prime example of an unfortunate sportsman with an unknown underlying cardiomyopathy who succumbed to his disease.

CASE DESCRIPTION

The deceased, a 33-year-old state level bodybuilder, was participating in a bodybuilding competition when he suddenly complained of dizziness and collapsed. The practice of dehydrating oneself to "make weight" could not be established in this case.

He could not be resuscitated and was therefore shifted to a tertiary care hospital. Despite the quick transfer, the doctors declared the person "brought dead". Given the sudden unnatural nature of the death, a police inquest was conducted, and the body was sent for autopsy.

On autopsy, externally, no specific findings were present. Internal examination, however, revealed that the heart was enlarged and weighed 698g (Fig. 1) with a circumference of 36 cm. The left ventricular wall was hypertrophied, and the thickness was 3 cm. The right ventricular wall was 2.8 cm thick and was also hypertrophied. The apex was rounded, with the mitral valve measuring 12 cm and the tricuspid valve measuring 9 cm.

Fig. 1: Enlarged heart weighing 698 g.

On microscopic examination, ventricle sections showed enlarged myocytes with disarray and enlarged nuclei (Fig. 2 and 3). These findings are consistent with hypertrophic cardiomyopathy, and the cause of death was opined as "death due to complications of hypertrophic cardiomyopathy".

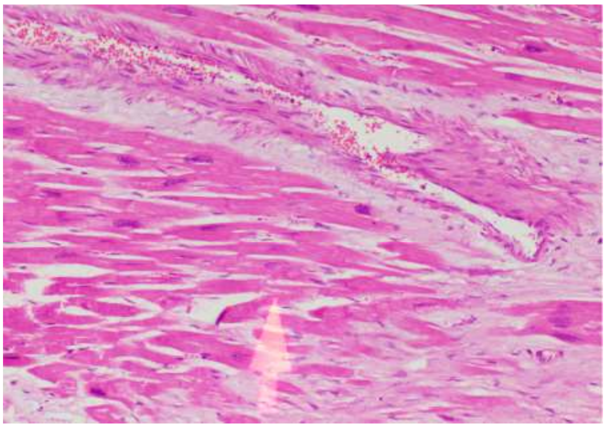

Fig. 2: Myocardium with fibrosis.

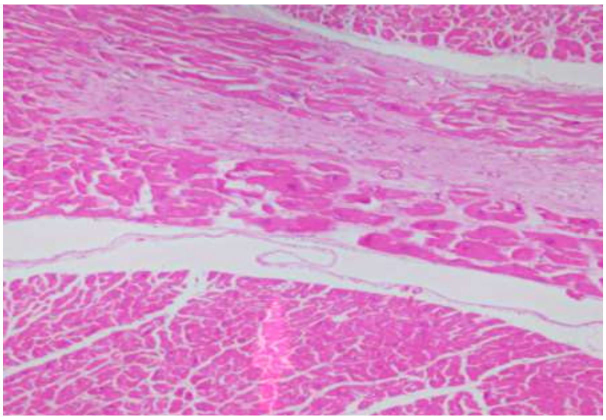

Fig. 3: Myocardial fibres with disarray.

DISCUSSION

Hypertrophic cardiomyopathy (HCM) is a common genetic disorder characterized by abnormal diastolic filling caused due to a poorly compliant left ventricular myocardium and myocardial hypertrophy.[6] There are several variants of HCM, including Mid cavity obstructive HCM, Mid cavity obstruction with LV apical aneurysm, Apical HCM, right ventricular obstruction, obstructive HCM in older adults, and end stage HCM.

In HCM, the left ventricular outflow tract obstruction is due to the mitral valve's systolic anterior movement or systolic anterior motion (SAM) make contact with the ventricular septum in phase of mid-systole. The mechanical resistance created by this exit of the blood from the heart causes a pressure differential between the left ventricle cavity and the aorta. In addition, during stress, there is diminished myocardial blood flow (i.e., "small vessel ischemia") consequent to an impairment in the vasodilatory capacity and diminished luminal cross-sectional area caused by structurally abnormal intramural coronary arterioles.

The histopathological findings in HCM include varying amounts of interstitial fibrosis intertwined among the myocytes, with hypertrophied myocytes arranged in a disorganized and chaotic fashion. Replacement fibrosis is also seen following myocyte cell death because of multiple small vessel ischemia and healing and repair mechanism.

Understanding the relationship between physical exertion and its effect on a hypertrophic heart is essential. The overall risk of acute coronary syndrome and atherosclerosis is reduced because of the positive pleiotropic effect from high intensity to moderate exercise, performed at repeated intervals.[7] This, however, is when the underlying heart is normal.

For an enlarged ventricle, during exercise, the catecholamine surge seen, interacts unfavourably with the core arrhythmogenic substrate, i.e., the enlarged ventricle itself in this case. Intense exercise can cause electrolyte imbalance, dehydration, hyperpyrexia, and increased platelet aggregation, further enabling ventricular fibrillation or tachycardia.[8]

The question now arises as to how to prevent such deaths. In one study, there was a drastic decline in the incidence of sudden cardiac death from 3.6/ hundred thousand person years to 0.4/hundred thousand person years, representative of a ninety percent reduction in sports related mortality with the use of ECG for pre-participation screening in a study conducted in Italy.[9] This simple, non-invasive procedure of an ECG, hence, has tremendous value in this context. In HCM, the ECG will show a large, inverted T wave.

Hence, a pre-participation assessment has proven beneficial when performed in competitive young athletes. The assessment consists of structured history taking and physical evaluation, and where required, an echocardiogram and electrocardiogram to identify the population at danger. Following this, supervised exercise training should be recommended, and lastly, resuscitative means should be readily accessible and available and applied in the rare event of an untoward cardiac incident.[7]

In athletes diagnosed with HCM, sports with surge action (sprinting and sports associated with it, such as basketball, football, hockey and other sports activities) are best avoided. Aerobic (not isometric) physical exertion is favoured. Physical activities should be performed in ideal or near-ideal environmental conditions. Replenishing fluids becomes very important in patients with HCM. In leisure sports activities (recreational activities), professional recommendations should be evaluated individually. These recommendations should consider the person's risk factors, particularly those predisposing to left ventricular outflow tract obstruction and ventricular arrhythmias. It is also essential to explain that even patients with hypertropia cardiomyopathy without all "classical" risk factors are not afforded safety from the risk of sudden cardiac death.[9]

CONCLUSION AND IMPLICATIONS FOR CLINICAL PRACTICE

The case presented brings to light the need for in-depth pre-competition screening of athletes. Non-invasive methods which do not use radiation can be used at the national level, such as Cardiac Magnetic Resonance (CMR) which provides an excellent view of the myocardium, but this test is expensive. However, the addition of electrocardiography is an inexpensive method as a screening test, leading the way for using tools such as CMR, serum biomarkers and genetic testing.[4] It is recommended that people with HCM should be excluded from all sports except low-intensity ones. Also, genetic counselling should be given to families of those with HCM and the deceased when autopsy findings reveal the cause of death as HCM.

REFERENCES

1. **Nystoriak MA, Bhatnagar A.** *Cardiovascular effects and benefits of exercise. Frontiers in cardiovascular medicine. 2018 Sep 28;5:135.*
2. **Paffenbarger Jr RS, Hyde R, Wing AL, Hsieh CC.** *Physical activity, all-cause mortality, and longevity of college alumni. New England journal of medicine. 1986 Mar 6;314(10):605-13.*
3. **Maron BJ, Gardin JM, Flack JM, Gidding SS, Kurosaki TT, Bild DE.** *Prevalence of hypertrophic cardiomyopathy in a general population of young adults: echocardiographic analysis of 4111 subjects in the CARDIA study. Circulation. 1995 Aug 15;92(4):785-9.*
4. **Maron MS, Hellawell JL, Lucove JC, Farzaneh-Far R, Olivotto I.** *Occurrence of clinically diagnosed hypertrophic cardiomyopathy in the United States. The American journal of cardiology. 2016 May 15;117(10):1651-4.*
5. **Semsarian C, Ingles J, Maron MS, Maron BJ.** *New perspectives on the prevalence of hypertrophic cardiomyopathy. Journal of the American College of Cardiology. 2015 Mar 31;65(12):1249-54.*
6. **Kumar V, Abbas A, Aster J.** *Robbins & Cotran Pathologic Basis of Disease: South Asian Edition. 1st ed. Vol. 1. Elsevier India; 1st edition (14 August 2014); 2014. 568-569 p.*
7. **Vora A, Burkule N, Contractor A, Bhargava K.** *Prevention of sudden cardiac death in athletes, sportspersons and marathoners in India. Indian heart journal. 2018 Jan 1;70(1):137-45.*
8. **Chandra N, Bastiaenen R, Papadakis M, Sharma S.** *Sudden cardiac death in young athletes: practical challenges and diagnostic dilemmas. Journal of the American college of cardiology. 2013 Mar 12;61(10):1027-40.*
9. **Corrado D, Schmied C, Basso C, Borjesson M, Schiavon M, Pelliccia A, Vanhees L, Thiene G.** *Risk of sports: do we need a pre-participation screening for competitive and leisure athletes?. European heart journal. 2011 Apr 2;32(8):934-44.*


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Reports of randomized clinical trials should be based on the CONSORT Statement. (www.consort-statement.org) When reporting experiments on human subjects, indicate whether the procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional or regional) and with the Helsinki Declaration of 1975, as revised in 2000 (available at http://www.wma.net/e/policy/l 7-c_e.html).

Supplementary materials and technical details can be placed in an appendix where it will be accessible but will not interrupt the flow of the text; alternatively, it can be

Result

Present your results in a logical sequence in the text, tables, and illustrations, describing the most important findings first. Do not repeat the data in the tables or illustrations; emphasize or summarize only important published only in the electronic version of the journal.

Discussions

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

References

References should be listed in alphabetical order and numbered accordingly. Each listed reference should be cited in the text. Identify references in text, tables, and legends by Arabic numerals in square bracket (e.g. [10]). Please refer to ICMJE Guidelines (http://www.nlm.nih.gov/bsd/uniform_ requirements.html) for more examples.

Standard journal article

- 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.
- 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

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

Corporate (collective) author

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

Unpublished article

- 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)

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

Chapter in book

- Nauntofte B, Tenovuo J, Lagerlöf F. Secretion and composition of saliva. In: Fejerskov O,

No author Listed

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

Reference from electronic media

- 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.
- More information about other reference types is available at www.nlm.nih.gov/bsd/uniform_ requirements.html, but observes some minor deviations (no full stop after journal title)

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- Tables should be self-explanatory and should not duplicate textual material.
- Tables with more than 10 columns and 25 rows are not acceptable.
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- For footnotes use the following symbols, in this sequence: *, ¶, †, ‡‡,

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