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Morphological variations of mandibular sigmoid notch in children aged 4-14 years

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Highlights

- This study will help pediatric dentists to identify different variations in the morphology of mandibular sigmoid notch.
- The information about morphological variations of the mandibular sigmoid notch obtained would allow a maxillofacial surgeon to treat chronic mandibular dislocations properly.
- The information regarding different shapes of sigmoid notch is useful in forensic sciences based on the influence of transition from primary to permanent dentition.

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Abstract

Aim: The sigmoid notch additionally known as the mandibular notch is a deep notch setting apart the coronoid process and the condyle. Different morphological variations of sigmoid notch (wide, round and sloping) have been documented in literature as indispensable aids in anthropological and forensic research. The study aimed to assess the morphological appearance of sigmoid notch during primary dentition, mixed dentition and permanent dentition. **Methods**: 400 panoramic images of 194 boys and 296 girls were collected and divided into three groups bases on the stage of dentition. Shape of the sigmoid notch was determined by tracing the print out of the panoramic image on an x-ray viewer. **Results:** It was observed that during primary and mixed dentition stage shape of the sigmoid notch was wide and as growth and development occured during permanent dentition stage the sigmoid notch shape changed to round. **Conclusions**: This study describes the normal morphology of mandibular sigmoid notch in children during primary, mixed and permanent dentition and also states that growth of craniofacial region has a significant role in determining sigmoid notch morphology.

Keywords: Mandible; Panoramic Radiography; Sigmoid Notch

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INTRODUCTION

The adult mandible is considered as the largest bone in the face, it includes ascending rami one on either side that in turn bears the coronoid and condyle process. The coronoid process is a flat triangular plate that projects upwards and barely forwards, while the condyle is a rounded projection that articulates with the glenoid fossa of the temporal bone. The sigmoid notch; additionally known as the mandibular notch is a deep notch setting apart the coronoid process and the condyle.[1]

Different morphological variations of sigmoid notch (wide, spherical and sloping) had been documented in literature among different age groups and individuals as indispensable aids in anthropological and forensic research.[2] These variations arise due to the genetic history or due to remodeling of condyle to accommodate developmental changes, functional modifications that arise with the development and growth, trauma and other degenerative pathologies and abnormilities. The assessment of sigmoid notch may be used as an indicator of TMJ disorders (TMDs). Therefore, dental clinician needs to recognize the difference among abnormal and normal morphology of sigmoid notch to assist diagnosing and treating signs and symptoms of TMDs at an early stage. Till date most of the studies had been carried out using the dry mandibles obtained from the cadavers of the deceased individuals.

Maxillofacial surgeons consider the region due to its clinical importance for surgical approach, reconstructive purposes, surgical approach and management of the surgery.[3] The information about morphological forms of the sigmoid notch obtained would allow a maxillofacial surgeon to treat chronic mandibular dislocations properly through a novel mini-plate introduced by Cavalcanti and Vasconcelos.[3] Variations in the contour of the sigmoid notch acts as an evolutionary marker and can be used in anthropological studies and in forensic studies. Panoramic radiographs can be a preferred imaging method to detect possible morphological modifications on the mandibular bone and can be used in forensic sciences based on the influence of aging on sigmoid notch morphology and would help forensic doctors to predict the status of dentition and if someone is younger or older.[4]

Radiographs play a vital role in forensic dentistry to locate the hidden information that cannot be easily determined through regular physical examination. Maxillofacial radiography with the resource of orthopantamogram is used as a routine screening tool in the diagnosis and treatment plans in several fields of dentistry and is found to be much less pricey whilst in comparison to different advanced imaging modalities like CT, MRI and CBCT.[5] Panoramic imaging offers crucial information that can be useful for early evaluation of TMDs as it offers a two-dimension anatomical picture of sigmoid notch that acts as important elements in TMJ.

A thorough understanding and knowledge of the morphology and anatomy of sigmoid notch is essential to distinguish between normal variant and the pathological conditions. According to the current literature, no study has been conducted to date, so the purpose of the present study is to recognize the general morphology of sigmoid notch in pediatric patients aged 4-15 years. The null hypothesis states that there is no change in the contour of sigmoid notch in primary, mixed and permanent dentition. Therefore in this study we aim to view the morphological appearance of sigmoid notch during primary dentition, mixed dentition and permanent dentition by using orthopantogram.

METHODS

Sample

This cross-sectional study was conducted using 400 orthopantomograms (OPGs) in children

aged between 4 years and 15 years at the Department of Pedodontics and Preventive Dentistry, D Y Patil Dental School, Pune. Participants were randomly divided into three groups based on their dentition stage as primary dentition, mixed dentition, and permanent dentition. Ethical clearance to conduct the study was obtained from institutional ethical review board.(Ref No. 564/2022-23). Prior to the study, nature of the study was explained to the parents and their written consent was taken for participation of both parents and children in the study.

Panoramic radiographs of the participants were taken using a panoramic component Orthophos DS; Sidexis XG for children with exposure of 14.1 s at 62 kVp and 8 Ma. Participants aged between 4 and 14 years with known date of birth and who showed normal growth and development clinically with no history of trauma or injury to the face were included in the study. Participants with known congenital anomaly, developmental, and/or systemic disorders, history TMD, congenitally missing, impacted, or transposition of teeth and those undergoing orthodontic treatment were excluded in the study.

All the OPGs recorded by the suitable methods without any alterations were included, and those with the presence of any developmental anomalies, maxillofacial trauma, or any other diseases affecting the mandible were excluded from the study. The prints out of 400 OPGs were traced using pencil over projection sheets with the help of the viewer box. The radiographs, thus, obtained were subjected for the assessment of the various morphological shapes of the sigmoid notch (deep notch separating the coronoid process and condyloid process) on an x-ray viewer by a single independent observer to reduce any chances of bias. The principle investigator assessed the morphological of sigmoid notch on two separate occasions to ensure reliability and validity The various shapes (wide, round, sloping) of the sigmoid notch were interpreted as given by Shakya *et al.*[2] These shapes were recorded for both right and left sides using each panoramic image including both the gender. Thus, a total of 800 sides were assessed for the sigmoid notch changes observed in primary dentition, mixed dentition, and permanent dentition.

The recorded data was compiled and entered in a spreadsheet (Microsoft Excel) and then exported to data editor of SPSS Version 20.0 (SPSS, IBM, India). Data were summarized as frequencies. The gender-wise and sidewise distribution of sigmoid notch shapes were tested by employing Chi-square test. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Of 400 digital OPG images obtained, corresponding to 800 sides, among which, 194 (336 sides) were of girls and 206 (464 sides) were boys. Distribution of all 400 participant's condylar head shape according to the stage of dentition is shown in Table 1.

Table 1. Distribution of sigmoid notch shapes on the right and left sides

Shape	Right side	Left side	Total	p- value
Sloping	116	111	227	
Wide	151	153	304	0.938
Round	133	136	269	
Total	400	400	800	

The shape of the sigmoid notch commonly observed was the wide i.e 304 (Figure 1), distributed as 151(49.4%) on the right and 153(50.6%) on the left side. The next shape commonly observed was round i.e 269 (Figure 2) distributed as 133(49.4%) on the right and 136(50.6%) on the left side and lastly the sloping

form i.e 227 (Figure 3) with 116(51.6%) and 111(48.4%) on the right and left sides respectively as shown in Table 1.

In boys during primary dentition stage sidewise distribution of sigmoid notch showed 14 and 14 round form of sigmoid notch in right and left sides respectively followed by 23 wide form on right side and 22 on left side. The least form was sloping with 14 on right side and 13 on left side. The distribution of sigmoid notch in boys among right and left sides during primary dentition had shown no statistical significant difference (Table 2).

During mixed dentition stage in boys sidewise distribution of sigmoid notch showed 40 and 42 round form of sigmoid notch in right and left sides respectively followed by 44 wide form on right side and 45 on left side. The least form was sloping with 31 on right side and 30 on left side. The distribution of sigmoid notch in boys among right and left sides during mixed dentition had shown no statistical significant difference (Table 3).

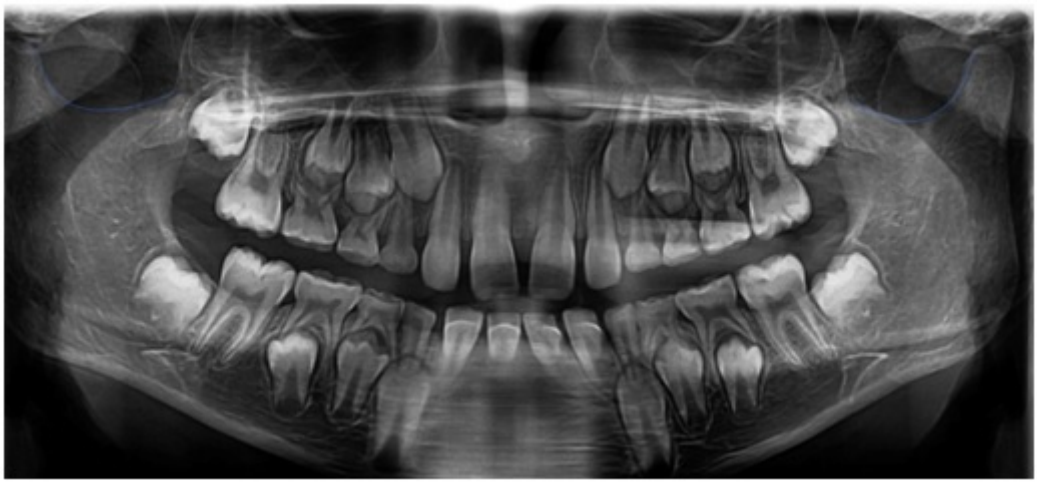

Figure 1. Representative panoramic image showing wide sigmoid notch

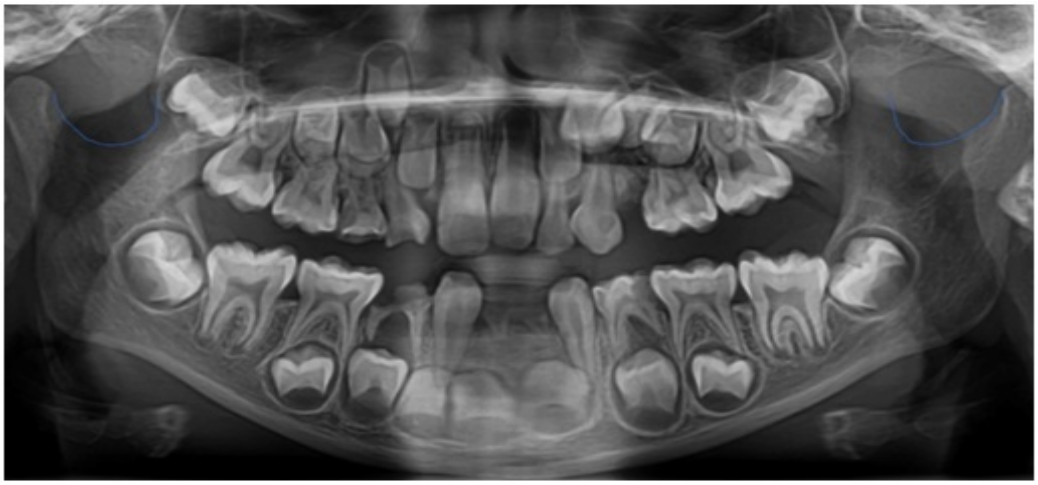

Figure 2. Representative panoramic image showing round sigmoid notch

Figure 3. Representative panoramic image showing sloping sigmoid notch

Table 2. Comparison of sigmoid notch shapes on the right and left sides in primary dentition for boys

Shape	Right	Left	p- value
Sloping (n=27)	14 (51.8%)	13 (48.2%)	p =0.914
Wide (n=45)	23 (51.1%)	22 (48.8%)	p =0.935
Round (n=28)	14 (50%)	14 (50%)	p = 1.000

Table 3. Comparison of sigmoid notch on the right and left sides in mixed dentition for boys

Shape	Right	Left	p- value
Sloping (n=61)	31 (50.8%)	30 (49.2%)	p =0.951
Wide (n=89)	44 (49.4%)	45 (50.6%)	p =0.904
Round (n=82)	40 (48.8%)	42 (51.2%)	p = 0.873

Sidewise distribution of sigmoid notch in boys during permanent dentition stage showed 12 and 12 round form of sigmoid notch in right and left sides respectively followed by 10 sloping form on right side and 10 on left side. The least form was wide with 06 on right side and 06 on left side. The distribution of sigmoid notch in boys among right and left sides during permanent dentition had shown no statistical significant difference (Table 4).

Table 4. Comparison of sigmoid notch on the right and left sides in permanent dentition for boys

Shapes	Right	Left	p- value
Sloping (n=20)	10 (50%)	10 (50%)	p = 1.000
Wide (n=12)	06 (50 %)	06 (50 %)	p = 1.000
Round (n=24)	12 (50 %)	12 (50 %)	p = 1.000

In girls during primary dentition stage sidewise distribution of sigmoid notch showed 24 and 25 wide form of sigmoid notch in right and left sides respectively followed by 15 round form on right side and 15 on left side. The least form was sloping with 15 on right side and 14 on left side. The distribution of sigmoid notch in girls among right and left sides during primary dentition had shown no statistical significant difference (Table 5).

Table 5. Comparison of sigmoid notch shapes on the right and left sides in primary dentition for girls

Shape	Right	Left	p- value
Sloping (n=29)	15 (51.8%)	14 (48.2%)	p =0.783
Wide (n=49)	24 (48.9 %)	25 (51.1 %)	p = 0.821
Round (n=30)	15 (50%)	15 (50%)	p = 1.000

During mixed dentition stage in girls sidewise distribution of sigmoid notch showed 49 and 49 wide form of sigmoid notch in right and left sides respectively followed by 45 round form on right side and 46 on left side. The least form was sloping with 36 on right side and 35 on left side. The distribution of sigmoid notch in girls among right and left sides during mixed dentition had shown no statistical significant difference (Table 6).

Table 6. Comparison of sigmoid notch shapes on the right and left sides in mixed dentition for girls

Shapes	Right	Left	p- value
Sloping (n=71)	36 (50.7%)	35 (49.3%)	p = 0.961
Wide (n=98)	49 (50 %)	49 (50 %)	p = 1.000
Round (n=91)	45 (49.4 %)	46 (50.6 %)	p = 0.914

Sidewise distribution of sigmoid notch in girls during permanent dentition stage showed 9 and 10 sloping form of sigmoid notch in right and left sides respectively followed by 7 round form on right side and 7 on left side. The least form was wide with 05 on right side and 06 on left side. The distribution of sigmoid notch in girls among right and left sides during permanent dentition had shown no statistical significant difference (Table 7).

Table 7. Comparison of sigmoid notch shapes on the right and left sides in permanent dentition for girls

Shapes	Right	Left	p- value
Sloping (n=19)	9 (47.3 %)	10 (52.7 %)	p = 0.848
Wide (n=11)	5 (45.4 %)	6 (54.6 %)	p = 0.693
Round (n=14)	7 (50 %)	7 (50 %)	p = 1.000

DISCUSSION

The mandible is the most durable and sexually dimorphic bone of the skull, and it is also known to resist post-mortem changes. Mandible and tympanic ossicles are the only mobile bones of the skull.5 Muscle attachment and function may dynamically affect the shape and orientation of the contours of the mandible. Attachment and action of temporalis and masseter muscle alter the shape of condyle and coronoid. Genetic determinants, hormonal variation in condyle, and coronoid itself can lead to different "shapes" of the sigmoid notch.[6]

The mandibular notch, appears as a gap facing upwards and slightly backwards occupied the upper border of the ramus of the mandible.[3] Its opening is bordered by coronoid process from anterior margin and condylar process from posterior margin. Contour of mandibular notch are depending on configurations of the coronoid processes, condyle process and its neck in addition to the form of indentation of the upper portion of ramus of mandible. Orthopentogram has been described to be reliable in representing the sigmoid notch and in evaluating the temporomandibular joint abnormalities.[7] These radiographs serve as ante-mortem records in personal identification process. Participants in the study were divided into three different groups based on their stage of dentition period i.e., primary dentition, mixed dentition, and permanent dentition.

Morphological variations of anatomic structures arise either corresponding to the developmental discrepancies through hereditary determinants or because of the functional variations that arise during the growth and development process[8]. Different shapes of the sigmoid notch were assessed with help of orthopanoramic images.

The shape of sigmoid notch depends on the shape of coronoid process and mandibular condyle. According to the direct visual inspection, contours were classified into three types: Wide, round and sloping. The sloping shaped sigmoid notch, had two dimensions represented by condylar and coronoid processes meeting at an angle, pointing downwards and indent bottom of the mandibular notch. Also in this type, the coronoid projection is shorter than condylar projection so they will form right mark appearance. This was presented bilaterally in 108 boys and 119 in girls. In mandible without any angulations, the mandibular notches looked rounded shape appeared as smooth curve like a half circle bordered by the same extensions of condyle with its neck and coronoid processes. This was seen bilaterally in 134 boys and 135 in girls. The wide shape was similar to the rounded shape but the bottom here take the shape of straight line more than curved appeared as like a half circle bordered with increase in the distance between condyle and coronoid processes in male mandibles. This was presented bilaterally in 146 boys and 158 in girls.

To the best of our knowledge this is the first study evaluating the variations in the morphology of sigmoid notch in children in primary, mixed and permanent dentition. The study showed the prevalence of wide shaped sigmoid notch in boys and girls in primary and mixed dentition with no significant changes on both sides. However in permanent dentition the most common shape was sloping followed by round.

The wider form of the sigmoid notch was most common among boys in both primary dentition and mixed dentition period followed by the round and sloping forms showing no statistical difference in the shape of sigmoid notch $p>0.05$. However in permanent dentition period the round form was more prevalent which can be attributed to the growth and development occurring during permanent dentition stage. These results are in accordance to the study reported by Dathar Sahithi et al[9], Ashwinirani SR et al[10] and Manpreet Manoj et al.[11].

The wider form of the sigmoid notch was most common among girls in both primary dentition and mixed dentition period followed by the round and sloping forms showing no statistical difference in the shape of sigmoid notch $p>0.05$. However in permanent dentition period the sloping form was more prevalent as against those of boys in permanent dentition where round form was more prevalent. This is in accordance to the study conducted by Shrijana Shakya et al[2], Varsha Kanjani et al.[12], Ashwinirani SR et al.[10] and Manpreet Manoj et al. [11] Studies conducted by Shazia Maqbool et al.[13] and Melek Tassoker et al.[14] on adult population showed round form of sigmoid notch more common in males and females. Configurations of the coronoid process, mandibular condyle and mandibular notch are developmentally connected to each other.[15] Contours of the coronoid and condylar processes are particularly important for formation of the mandibular notch. However, such formations may morphologically differ depending on genetic factors, hormones, nutritional habits and activity of the temporalis muscle. There are studies where different configurations of such formations were detected in the literature.

The sigmoid notch form did not significantly change on either side according to our findings. We did notice a combination of different shapes on either side, but it did not statistically signify

anything. Through inherited determinants and functional changes that occur during the growth phase, morphological variances are produced by corresponding developmental variations. Muscle and bone may dynamically influence one another's function and change the morphology of the affected bone.[2] The coronoid and condylar processes' shapes influence how the sigmoid notch might vary.[2,11]As the variation of all three shapes when compared on either side and among both boys and girls were not statistically significant, the significance of hormonal influence is also debatable.

CONCLUSIONS

The present study was conducted to explore the most prevalent radiographic shapes of the mandibular sigmoid notch in children during different stages of development of dentition using panoramic radiograph. The most common shape of sigmoid notch seen in primary dentition stage and mixed dentition is wide form. While in permanent dentition stage the shape of sigmoid notch is sloping. No such study has been carried out in the Indian population in children. Since this study has small sample size, larger sample sizes with are required to follow the variation of mandibular notch outline from newborn up to adult ages in order to be more precise for its usage in person identification. The present study can be further conducted using precise modality using cone-beam computed tomography (CBCT).

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