Original Article

# Evaluation of Midpalatal Suture Ossification Based on Age and Gender Using Cone Beam Computed Tomography (CBCT)

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## Abstract

Objective: In patients with space deficiency problems and maxillary arch constriction problems, if the midpalatal suture is open, the suture can be opened using fixed orthodontic devices. Therefore, the closure of this suture makes it necessary to use more invasive treatments. In this study, we investigated the ossification of midpalatal suture based on age and gender in an Iranian population. Methodology: In this cross-sectional study, cone beam computed tomography images of two groups of patients (each included 89 patients) referring to the Oral Radiology Department of Tabriz Faculty of Dentistry were studied. The head was adjusted at two coronal and axial planes, and in the sagittal plane, the head was placed in the anterior-posterior axis parallel with the horizontal axis, and the sagittal palate incision was placed at software by displacing the head from front to back in the anterior or posterior direction of palatal plane parallel to the horizontal line. After placing a horizontal line along the palate, axial incisions in the superior-inferior dimensions with a thickness of 0.3 mm were prepared. Bone ossification stages by two maxillofacial radiology specialists. To examine the level of midpalatal suture ossification in different group ages and two genders, the Chi-square test in SPSS 11 software was used. Results: There was no statistically significant difference between the two genders. The results showed that there was a significant difference between different age ranges and midpalatal suture ossification. Conclusion: There was no difference in the level of ossification of midpalatal suture in male and female genders, but the study showed that the level of ossification increased with increasing the age.

**Keywords:** Cone-beam Computed Tomography Imaging, Midpalatal Suture, Spicule, Coronary Planes, Sagittal Plane, Axial Plane

## Introduction

Face sutures are important mediators of skeletal adaptation to craniofacial growth and biomechanical therapies [1]. From a morphological point of view, the suture has a spiral state containing convex and concave regions in which the collagen fibers are radially placed inside the suture mesenchyme from convex site to convex site [2]. Midpalatal suture is an end-to-end suture that starts at the posterior of the palatomaxillary suture and extends longitudinally to the nasopalatine foramen in the palatal bone, which is in the Y-shaped axis and consists of two parts of pre-maxilla and maxillary in the embryonic period and attaches to the vomer from the superior part [3, 4]. The process of suture ossification begins initially as the suture margin spicules movement toward the center and forms islets of incomplete ossification and cell-free tissue. Then, with the emergence of spicules from the margin of the suture, islets of cell-free tissue and incomplete ossification are created in the middle of suture [5]. The process of spicules formation occurs in different regions of the suture, and the number of spicules increases with the progression of maturation and they are

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placed closer to each other and are separated by connective tissue, which this view is described as toothed regions [6]. Imagining techniques such as bone beam computed tomography (CBCT) can be used to detect midpalatal suture ossification. The CBCT technique provides accurate images of hard tissue with the quality of CT images. Compared to CT images, it has advantages of the lower cost of using equipment, reduced patient imaging time, and reduced radiation received by the patient [7].

Skeletal age in different individuals based on their maturation is seen differently from chronological age. Skeletal growth is proportional to the skeletal growth of the whole body. Thus, individuals proportional to skeletal growth may show a different ossification pattern in the midpalatal suture at different ages [8]. One of the studies conducted on ossification of midpalatal suture is the study conducted by Tonello et al in 201, who found a significant relationship between midpalatal suture maturation and gender in investigating the midpalatal maturation based on Angelieri ossification stages [9].

Also, a study conducted by Haghanifar et al with regard to the level of ossification of midpalatal suture on CBCT images with Angelieri ossification stages indicated that the level of ossification of suture increases from a young age to middle age. This study also attributed the cause of open suture in middle-aged people aged above 50 years olds to a decrease in muscle strength due to aging and tooth loss or the use of a soft diet and a significant relationship was observed between males and females. Various studies have provided different results regarding age and sex at the time of bone mineralization of the midpalatal suture. Due to few studies in this area and inconsistency in the results of previous studies, the present study was conducted to assess the level of ossification of midpalatal suture with a larger sample size in an Iranian population.

## Methodology

### Type of study and population

This study is a cross-sectional study. A total of 178 patients (89 females and 89 males) referred to the radiology department of Tabriz University of Medical Sciences were selected as samples for the preparation of CBCT radiography for different reasons. All radiographies were performed for other diagnostic purposes such as implant placement. Inclusion criteria of the study included 10 to 70 years old people, absence of craniofacial anomaly in the region, absence of skeletal growth disorder and exclusion criteria included people with metal appliance in the palate region, present trauma or previous trauma in the region, systemic diseases or was taking drugs affecting bone density and poor quality images.

### Sample size and data collection method

G-power software was used to determine the sample size. Based on the results of studies by Haghanifar et al, with considering $\bar{\alpha} = 0.05$, 80% power, and midpalatal ossification level of 0% in stage A, 34% in stage C, 17% in stage D, and 47% in stage E, the sample number was determined 86 in each gender group and 176 in total. Research data were collected through computer software on CBCT images. The variables studied in this study were Stage A: straight lines with high density, Stage B: sutural lines with high density and toothed edge, stage C: two sutural lines with high density and parallel to each other and a little distance with each other, Stage D: complete ossification without observation of the sutural line, and Stage E: complete ossification of maxillary bone.

### Implementation

The birth date of the clients was recorded based on a valid identification document and informed consent was obtained from all of them. The clients referred for reasons other than orthodontic problems and midpalatal suture examinations. Clients' images were obtained by Newton VGi Cone Beam CT (Verona / Italy) in the Oral and Maxillofacial Radiology Department of Tabriz University of Medical Sciences. The device has a cone beam, flat panel detector, 1536 × 1920 pixels, 127 × 127 m2 pixels, 14-bit pixel depth, 360-degree rotation, 18-s scan time and a maximum constant voltage of 110 kVp and a variable current of 1-20mA. The initial and final restoration was done by NNT viewer version 5.6. The radiation conditions of the device were adjusted automatically. Data obtained from CBCT were entered into NNT viewer version 5.6 software and images were studied on 19-inch PHILIPS (190 B) LCD monitor with a resolution of 1024 × 1024 pixels and 32 bits in a semi-dark room by an oral and maxillofacial radiologist. To examine the morphology of midpalatal suture, the position of the head in NNT viewer version 5.6 software was observed and analyzed in the multi-planar part of the software. The head was adjusted in two coronal and axial planes according to the software reference lines, and in the sagittal plane, the head was placed in a position that the palate was parallel to the horizontal axis. In the sagittal view, by displacing the head in the anterior or posterior direction, the palatal plane was placed in parallel to the horizontal line embedded in the software. After placing the horizontal line alongside the palate, 30-mm axial incisions in the superior-inferior dimensions (from mouth to nose) were prepared. In patients with a curved palate, the anterior and posterior parts were not observed in a single plane, and the palatal bone was examined in separate anterior-posterior planes. In those with the thick palate, the axial incisions were increased to three incisions, including the inferior incision (near the mouth), the middle incision, and the superior incision (near the mouth) for closer examination. The accuracy of the information was evaluated by two maxillofacial radiology specialists. Kappa coefficient was calculated to evaluate the accuracy of diagnosis between two radiologists. Axial sections were used to examine the level of ossification.

### Data analysis method

The obtained data were entered into SPSS 17 software. A chi-square test was used to evaluate the bone maturation of

midpalatal suture in both age groups and two genders. A P-value of less than 0.05 was considered as significant level.

## Results

Figure 1 illustrates axial A, sagittal B, Coronal C planes in CBCT images.

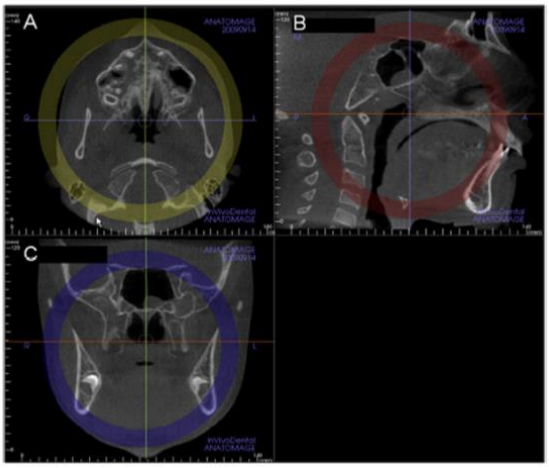


**Figure 1:** axial A, sagittal B, Coronal C planes in CBCT images

Figure 2 illustrates head displacement in the two anterior and posterior planes

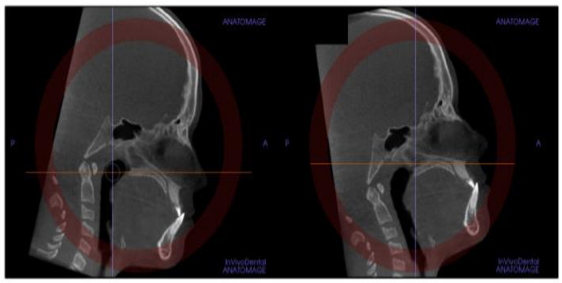

**Figure 2:** Head displacement in two anterior and posterior planes

The figure illustrates a sagittal view of the horizontal line drawn from ANS to PNS.

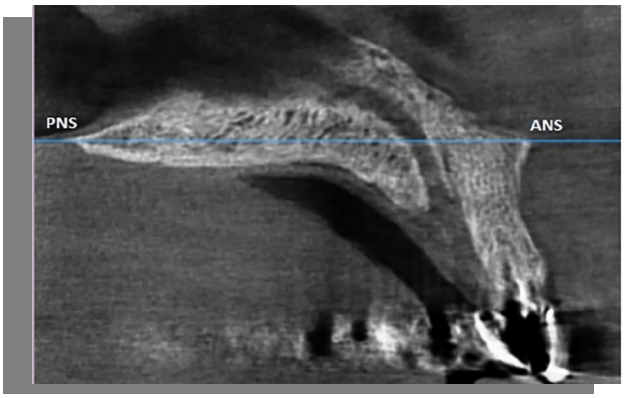


**Figure 3**: Sagittal view of the horizontal line drawn from ANS to PNS

Figure 4 illustrates the sagittal view of the curved plate.

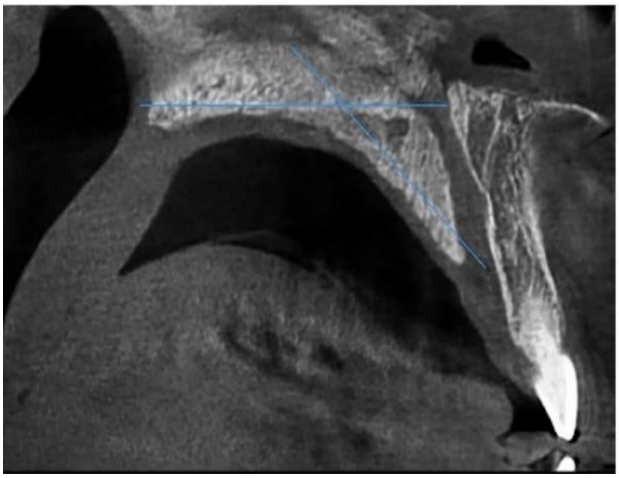

**Figure 4:** sagittal view of the curved palate

Figure 5 illustrates the morphology of the suture

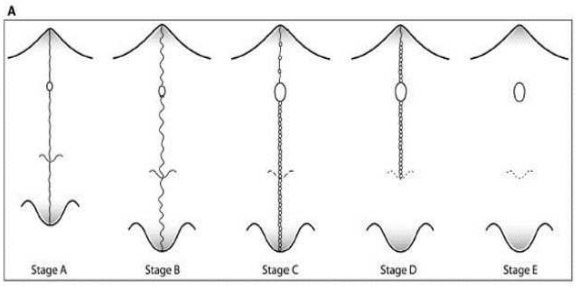


**Figure 5:** a schematic view of ossification stages

Stage A: straight lines with high density, Stage B: sutural lines with high density and toothed edge, Stage C: two sutural lines with high density and parallel to each other and a little distance with each other, Stage D: complete ossification without observation of the sutural line, and Stage E: complete ossification of maxillary bone (Figure 10).

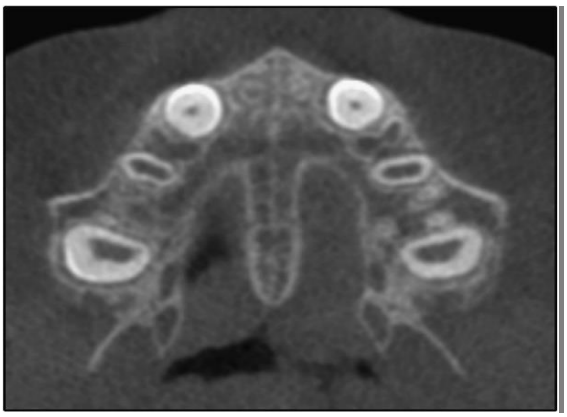

**Figure 6:** Stage A of ossification: straight lines with high density


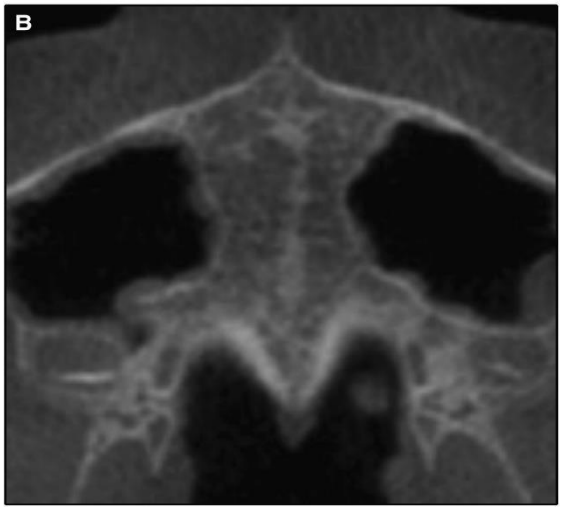


**Figure 7:** Stage B of ossification: sutural lines with high density and toothed edge

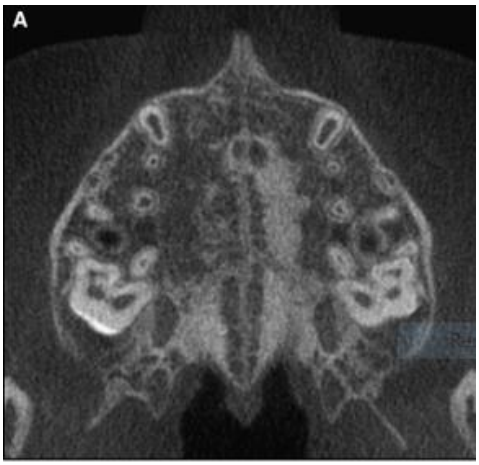


**Figure 8:** Stage C of ossification: two sutural lines with high density and parallel to each other and a little distance with each other

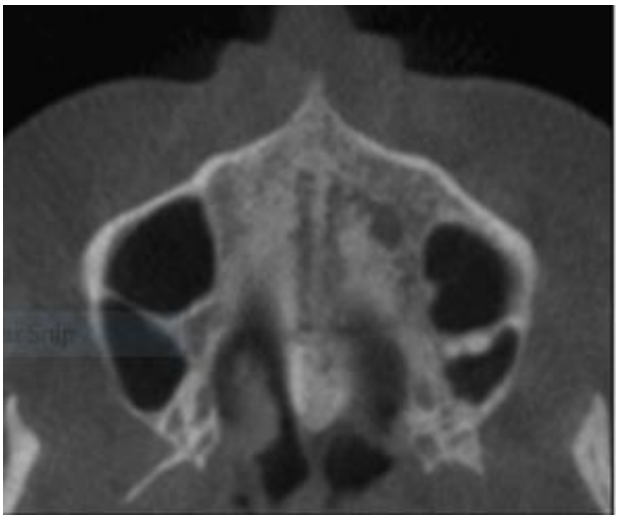

**Figure 9:** Stage D: complete ossification without observation of the sutural line

**Figure 10:** Stage E: complete ossification of the maxillary bone

The study used 178 CBCT stereotypes, 89 of which were female and 89 were male. A chi-square test was used to examine the midpalatal suture ossification. Table 1 shows the frequency and percentage of study participants based on age.

**Table 1:** Frequency and percentage of study participants based on age

| Age range | f | % |
|---|---|---|
| **10-19** | 12 | 7.1 |
| **20-29** | 18 | 10.7 |
| **30-39** | 42 | 24.9 |
| **40-49** | 40 | 23.7 |
| **50-59** | 37 | 21.9 |
| **60-69** | 20 | 11.8 |

Table 2 illustrates the frequency and percentage of the study participants based on the ossification stage. 14% of patients showed stage B of ossification, 40.4% showed stage C of ossification, 26.4% showed stage D of ossification, 19.1% showed stage E of ossification, and zero percent showed stage A of ossification.

**Table 2:** Frequency and percentage of the study participants based on the ossification stage

| Ossification stage | f | % |
|---|---|---|
| **A** | 0 | 0 |
| **B** | 25 | 14 |
| **C** | 72 | 40.4 |
| **D** | 47 | 26.4 |
| **E** | 34 | 19.1 |

Table 3 illustrates the frequency and percentage of the study participants based on sex and stage of ossification. Among the studied patients, 14 female patients (56%) and 11 male patients (44%) showed Stage B 35 female patients (48.6%) and 37 male patients (51.4%) showed Stage C, 23 female patients (48.9%) and 24 male patients (51.1%) showed stage D, 17 female patients (50%) and 17 male patients (50%) showed Stage E. Stage A was not observed in any of genders. A chi-square test was used to determine the significant relationship between gender of the study participants and the stage of ossification. The level of significance was considered at 0.05. The results of the Chi-square test (presented in Table 3) showed that there was no statistically significant relationship between gender of the study participants and the stage of ossification (P-value> 0.05).

**Table 3:** Frequency and percentage study participants based on gender and ossification stage

| Ossification stage | | Female | Male | Total | P-value* |
|---|---|---|---|---|---|
| **A** | | 0 | 0 | 0 | |
| **B** | F | 14 | 11 | 25 | .933 |
| | % | 56% | 44% | 100% | |
| **C** | F | 35 | 37 | 72 | |
| | % | 48.6% | 51.4% | 100% | |
| **D** | F | 23 | 24 | 47 | |
| | % | 48.9% | 51.1% | 100% | |
| **E** | F | 17 | 17 | 34 | |
| | % | 50% | 50% | 100% | |

*Chi-square test

The frequency and percentage of the study participants based on age and ossification stage are presented in Table 4. A chi-square test was used to determine the significant relationship between the age of participants and the ossification stage. The significance level was considered at 0.05. The results of the Chi-square test (shown in Table 4) showed that there was a statistically significant relationship between the age of the study participants and the osteoporosis stage (P-value <0.001). The descriptive statistics are as follows: stage A of ossification was not observed in any of the age groups, the highest percentage of stage B was observed in the age range of 10 to 19 years, stages C and D showed the highest percentage in the age range of 30 to 39 years and 40 to 49 years and this stage was not observed in the age range of 10 to 19 years, and stage E showed the highest percentage in the age range of 50 to 59 years.

**Table 4:** Frequency and percentage of study participants based on age and ossification stage

| Ossification stage | | 10-19 | 20-29 | 30-39 | 40-49 | 50-59 | 60-69 | Total | P-value* |
|---|---|---|---|---|---|---|---|---|---|
| **A** | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| **B** | F | 12 | 6 | 2 | 0 | 1 | 3 | 24 | <.001 |
| | % | 50% | 25% | 8.3% | 0% | 4.2% | 12.5% | 100% | |
| **C** | F | 0 | 7 | 26 | 20 | 11 | 5 | 69 | |
| | % | 0% | 10% | 37.7% | 29% | 15.9% | 7.2% | 100% | |
| **D** | F | 0 | 5 | 12 | 13 | 8 | 5 | 43 | |
| | % | 0% | 11.6% | 27.9% | 30.2% | 18.6% | 11.6% | 100% | |
| **E** | F | 0 | 0 | 2 | 7 | 17 | 7 | 33 | |
| | % | 0% | 0% | 6.1% | 21.2% | 51.5% | %21.2 | 100% | |

*Chi-squared test

## Discussion

Face sutures are important mediators of skeletal adaptation during craniofacial growth and biomechanical therapies that their morphology will normally change during growth [1]. In patients with space deficiency problems and maxillary arch constriction problems and irregularity of teeth, midpalatal suture openness is an important solution to these problems. Most studies investigating midpalatal sutures have inherently

some limitations [10, 11]. Occlusal radiography is the most common technique for evaluating the midpalatal suture region before the treatment of maxillary rapid expansion in routine orthodontic treatments [11]. Three-dimensional radiographies have been a new and effective method in the last four decades for obtaining 3-D cross-sectional images of a three-dimensional structure [1, 12].

In the present study, CBCT images of 89 women and 89 men were studied. The ossification stages of the midpalatal suture were evaluated using Angelieri procedures. According to the study hypothesis, there was no significant relationship between ossification level of midpalatal suture and gender, but the results showed a statistically significant relationship between ossification level of midpalatal suture and age, which is in line with the results of the studies conducted by Knaup [13], Thadani [14] and Guyen [15] and Haghanifar [16]. In the study conducted by Tonello [9], there was a significant relationship between the ossification od midpalatal suture and gender. In a histological study conducted by Presson and Thilander in 1977, the anatomical changes of the suture in 24 individuals aged between 15 and 35 years were examined and they concluded that the closure of some facial sutures starts during adolescence, the age range of 15 to 19 years, and the most complete closure is observed at the ages 20 to 25 years [17]. However, in the present study, the closure of the suture and its ossification stage were different at different ages and they increased with increasing the age. This difference was probably due to the smaller sample size and different age range of the participants and the different methods of the study.

According to a study conducted by Knaup et al (2004), there was a significant relationship between ossification of midpalatal suture and age, so that the width of suture is more in people aged below 25 years than that in people aged over 25 years and the highest bone density was observed in the age range of 18 to 63 years [13]. The results of this study are in line with those of the present study. In this study, the highest width of suture was observed in people aged 10-25 years. In the present study, the ossification level increased with increasing age and it was consistent with the result of the mentioned study. In a study conducted by Angelieri et al in 2015, they found that at the ossification stages of A, B, and C, related to adolescents age of up to 18 years, RME was possible and after that age and entering to Stage D, the prognosis of the treatment with RME declines [17]. The results of the mentioned study were different from those of the present study, in that the present study showed stages B, C was visible up to the age of 22, and according to these results, RME is possible up to this age.

In a study conducted by Tonello et al in 2017, there was a significant relationship between midpalatal suture and gender, so that ossification started earlier in females compared to boys [9]. However, no significant difference was found between the two genders in this regard in the present study, so the results of the two studies were not consistent. There were also differences between the results of the mentioned study and those of the present study regarding the relationship between the ossification of midpalatal and age. In a study conducted by Haghanifar et al on over 144 CBCT images of 10 to 70 years old people to examine the level of ossification of midpalatal suture, they found that ossification was significantly correlated with age. This study also attributed the openness of suture in adults aged over 50 years to reduced performance caused by aging and tooth loss or the use of a soft diet [16]. In the present study, due to the frequency of 4 people at stage B of ossification in the age group of 50-70 years, the cause of open suture was also attributed to the reasons mentioned above. The results of the study conducted by Haghanifar et al were consistent with those of the present study, except in one case, in which stage A of ossification was observed in their study (stage A was not observed in our study). However, both studies provided similar results regarding the association between the level of ossification of midpalatal suture and age.

## Conclusion

Therefore, in the present study, age made no difference in the level of ossification of midpalatal suture, but the results showed that there was an association between the level of ossification of midpalatal suture and age range of 10-70 years so that the level of ossification increased with increasing the age.

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