Position of the mandibular foramen in relation to the occlusal plane in children with skeletal class malocclusion

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SUMMARY

Frequently, practitioners use the inferior alveolar nerve block in the procedures desired on the teeth in the mandible and the surrounding tissues. This study aimed to reveal the position of the mandibular foramen (MF) according to the malocclusion types on panoramic radiographs of children aged 9-18 years living with malocclusion in Turkey. Panoramic and cephalometric radiographs of 330 patients between 9 and 18 years old were analyzed retrospectively. We grouped the skeletal malocclusion types as Class 1, 2, and Class 3 based on lateral cephalometric radiographs and evaluated the location of MF in malocclusion types according to age and gender. We observed that the distances to the occlusal plane, posterior edge, and gonion point increased with age while the distance to the anterior edge decreased. There was a significant difference according to age and gender in all malocclusion types ($p<0.05$). We determined that the MF was positioned upward parallel to the increase in age and approached the midpoint of the ramus of the mandible from the posterior. The fact that MF is placed higher than the occlusal plane in Class 3 malocclusions compared to other types and differs by gender will guide clinicians in providing effective and safe inferior alveolar nerve block in pediatric malocclusions.

Key words: Inferior alveolar nerve block – Malocclusion – Mandibular foramen – Occlusal plane – Panoramic radiograph

ABBREVIATIONS

IANB: Inferior alveolar nerve block

MF: Mandibular foramen

PR: Panoramic radiographs

OP: Occlusal plane

AP: Anteroposterior

mm: Millimeter

GO: Gonion point

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INTRODUCTION

One of the critical anatomical points in the ramus of the mandible is the mandibular foramen (MF). Passing vessels and nerves in the mandibular canal through MF is essential in dentistry and anatomy. Generally, clinicians prefer using inferior alveolar nerve block (IANB) for procedures they desire to perform on the teeth in the mandible and surrounding tissues. (Tüloğlu et al., 2010). For adequate anesthesia, the anesthetic solution should be injected around the MF (Moore et al., 2007). The failure of the IANB is due to the absence of intraoral bone markers indicating the injection site (Paryab et al., 2015). If the injection is administered more forward than MF, it cannot provide anesthesia; if administered too far back, introducing the needle into the parotid gland may cause temporary paralysis of the branches of the facial nerve unilaterally (Moore et al., 2007).

The repetition of the injection occurs due to unsuccessful anesthesia application. Repeated injection attempts cause fear and anxiety, especially in children, negatively affecting treatment (Tüloğlu et al., 2010). The occlusal plane (OP) and the anteroposterior (AP) position of the ramus of the mandible are referenced in determining the needle insertion site in IANB. In studies conducted in different races in the literature, it was reported that MF in children with deciduous teeth is at the OP level, slightly above OP during the mixed dentition period, and is displaced upward with increasing age (Afsar et al., 1998; Hwang et al., 1990; Movahhed et al., 2011). In addition, studies show a difference in the OP and AP position of MF compared to adults and children (Benham, 1976; Hwang et al., 1990; Kang et al., 2013).

In a retrognathic position relative to the maxilla in newborns, the mandible shows rapid growth and development, ensuring harmony between the maxilla. This is achieved by the combination of morphological and functional variables such as the eruption of teeth, enlargement of the tongue, lips, and cheeks, the movement and strength of the muscles attached to the mandible, swallowing and feeding habits, as well as the volumetric changes seen in the ramus and body of the mandible (Gill et al., 2013).

Malocclusion, defined as the disruption of normal occlusion during the growth and development period, causes the teeth, jaw, facial bones, and soft tissues to be affected. It leads to developmental problems or functional disorders such as chewing (Öz et al., 2019). There are nutritional habits, genetic and environmental factors in the etiology of malocclusion.

During the development of the mandible, changes are observed in the vertical and horizontal height of the ramus of the mandible (Gill et al., 2013). In the study conducted by Paryab and Ahmadyar (2019), it was reported that there was a difference in MF position due to age in patients with malocclusion. In addition, it has been found that the OP and AP positions of MF show differences between the classes of malocclusion in adult individuals with malocclusion (Park et al., 2015).

In the literature review, there are very few studies about MF positions in pediatric patients with malocclusion (Park et al., 2015; Paryab et al., 2015). As far as we know, the study investigating the position of MF in pediatric patients with malocclusion in Turkey could not be detected. This study aimed to reveal the position of the MF according to the malocclusion classes on panoramic radiographs (PR) of children with malocclusion aged 9-18 living in Turkey.

MATERIALS AND METHODS

In this study, panoramic and cephalometric radiographs of a total of 330 patients between 9-18 years old registered in the archives of the Department of Oral, Dental and Maxillofacial Radiology of the Faculty of Dentistry of Necmettin Erbakan University (Konya-TURKEY) were examined.

A single cephalometric and panoramic radiography (Morita Veraviewepocs 2D R100-P; J MoritaMFG, Kyoto, Japan) device was used to obtain the images in the study. The device is set to 70 kVp, 10 mA, and 10 seconds. The images were obtained by a single technician and according to the reference points specified by the manufacturer. The images were then exported as TIFF files. After the recorded images were set to 2836x1500 pixels with Photoshop CS6 Portable (Adobe Systems Onc. San Jose, CA, ABD), millimetric (mm) measurements were made.

Approval was obtained from Necmettin Erbakan University, Meram Faculty of Medicine, Non-Pharmaceutical and Medical Device Research Ethics Committee (Number: 14567952-050/673, decision number 2020/2497). Individuals between the ages of 9 and 18 with both panoramic and cephalometric radiographs were included in the study. The study did not include those with a previous history of trauma, those who had undergone surgery, individuals with facial and neck anomalies, and images that did not show clear bone boundaries due to poor image quality or images containing radiological artifacts.

The skeletal malocclusion types were grouped as Class 1, Class 2, and Class 3 according to Steiner's ANB angle based on lateral cephalometric radiographs (Point A: the deepest anterior point on the buccal face of the body of maxilla, Point N: Nasion, Point B: the deepest anterior point on the buccal face of the body of mandible, ANB angle: the angle formed by the NA and NB planes), (Fernandez et al., 2018), (Class 1: ANB° = 0° to 4°; Class 2: ANB°> 4°; Class 3: ANB°<0°).

The patients were divided into 9-13 years old and 14-18 years old groups according to their chronological age. The anterosuperior fossa of the posterior lingula of the mandible was determined as MF, 8 points were determined by reference to the study conducted by Movahhed et al. (2011) (Fig. 1) and by creating three planes, distance measurements of the MF to the surrounding anatomical points were performed.

Point 1. The most anterosuperior point of the lingula of the mandible.

Point 2. The most prominent point on the canine tooth crown.

Point 3. The uppermost tubercle crest of the erupted most posterior molar tooth in the mandible.

Point 4. The deepest point of the margo anterior of the ramus of the mandible.

Point 5. The most protruding point of the coronoid process.

Point 6. The most prominent posterior point on the condylar process.

Point 7. The most prominent point on the margo posterior, close to the angle of the mandible.

Fig. 1.- Example display of determined points on the panoramic radiographic image (Point 1: The most anterosuperior point of the lingula of the mandible. Point 2: The most prominent point on the canine tooth crown. Point 3: The uppermost tubercle crest of the erupted most posterior molar tooth in the mandible. Point 4: The deepest point of the margo anterior of the ramus of the mandible. Point 5: The most protruding point of the coronoid process. Point 6: The most prominent posterior point on the condylar process. Point 7: The most prominent point on the margo posterior, close to the angle of the mandible. Point 8: The angle at the intersection of the tangents drawn from the body of the mandible and the ramus of the mandible to the angle of the mandible, the location of the bisector of the angle of the mandible).

Point 8. Gonion point (GO). The angle at the intersection of the tangents drawn from the body of the mandible and the ramus of the mandible to the angle of the mandible, the location of the bisector of the angle of the mandible (Movahhed et al., 2011).

Plane 1: The plane connecting points 2 and 3 (OP).

Plane 2: The plane connecting points 4 and 5.

Plane 3: The plane connecting points 6 and 7.

U1: The line length is drawn perpendicular from Point 1 to Plane 1.

U2: The line length is drawn perpendicular from Point 1 to Plane 2.

U3: The line length is drawn perpendicular from Point 1 to Plane 3.

U4: The length of point 1 to GO.

To determine the position of MF on each image, we performed our measurements by using the defined points on the right and left sides of the mandible (Fig. 2).

The data were analyzed with IBM SPSS v23 software (NY, USA). The Shapiro-Wilk test checked normality distributions of quantitative data, and the Levene test checked homogeneity. Parametric evaluations were performed for those who had n>30 parametric conditions. The comparison of the data showing normal distribution was performed with the independent sample t-test. The comparison of more than two groups was performed by One Way ANOVA. In the intergroup evaluations, Post-Hoc was evaluated by multiple comparisons. The correction was made by the Bonferroni test in multiple group comparisons. In the study, the presence and direction of the relationship between MF parameters and the relationship between the parameters and age were determined decisively by Pearson correlation.

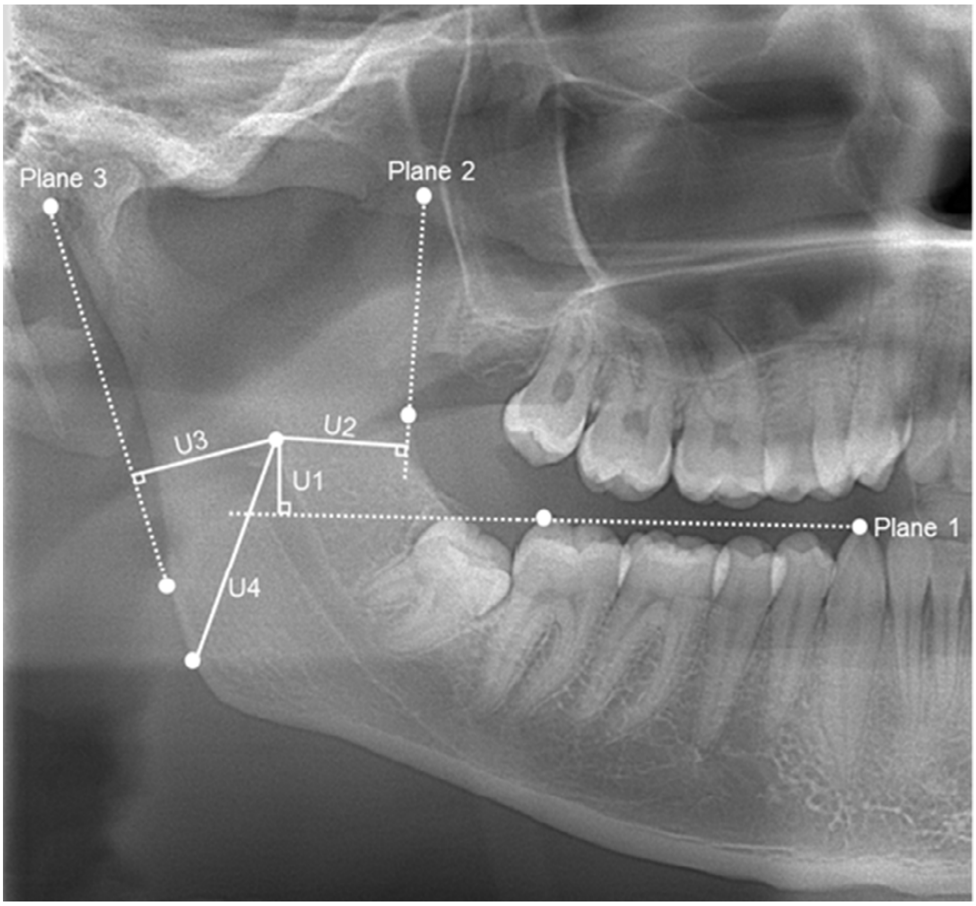

Fig. 2.- Example representation of U1, U2, U3, and U4 distance measurements on the panoramic radiographic image (U1: Length of the line drawn perpendicular to Point 1 to Plane 1. U2: Length of the line drawn perpendicular to Point 1 to Plane 2. U3: Length of the line drawn perpendicular to Point 1 to Plane 3. U4: Point 1 length of to GO).

Table 1. Gender distribution by malocclusion classes.

	Girl	Boy	Total
Malocclusion	Number (%)	Number (%)	Number (%)
Class 1	76 (23.03)	60 (18.18)	136 (41.21)
Class 2	74 (22.42)	35 (10.61)	109 (33.03)
Class 3	52 (15.76)	33 (10.00)	85 (25.76)
Total	202 (61.21)	128 (38.79)	330 (100)

The data were shown in the form of mean ± standard deviation. The significance level was accepted as $p<0.05$ for all statistical tests in the study.

RESULTS

A total of 330 children (202 girls and 128 boys) were included in our study. The gender distribution in malocclusion classes is shown in Table 1.

According to lateralization, the distance of MF to the anterior edge on the right side was significantly higher in Class 1 and Class 2 malocclusion, and the distance to GO on the left side was significantly higher in Class 2 malocclusion. There was no significant difference between the right and left measurement values in Class 3 malocclusion ($p>0.05$).

Regarding gender, men had significantly greater distances from MF to GO in Class 1 and Class 2 malocclusion and from MF to the anterior edge, posterior edge, and GO in Class 3 malocclusion. ($p<0.05$).

Based on the age groups, the distances from MF to OP, posterior edge, and GO in Class 1 and Class 2 malocclusion and from MF to the posterior edge and GO in Class 3 malocclusion were notably higher in the 14-18 age group. ($p<0.05$) (Table 2).

Although we highly measured the MF distances to the anterior edge in the 9-13 age group in all malocclusion classes, they were not statistically significant ($p>0.05$). Measurements of the distance of MF to OP, posterior edge, and GO showed a positive directional correlation with age, and the distance of MF to the anterior edge showed a negative directional correlation (Table 3).

There was a significant difference between the malocclusion classes in the distance of the MF to the OP and the anterior edge ($p<0.05$). The OP to the distance of MF was measured to be the highest in the Class 3 malocclusion group and the lowest in the Class 2 malocclusion group. The distance of MF to the anterior edge was the highest in Class 2 malocclusion and the lowest in Class 1 malocclusion (Table 4).

Table 2. Difference between malocclusion classification of parameters according to age groups (U1: The line length is drawn perpendicular from Point 1 to Plane 1. U2: The line length is drawn perpendicular from Point 1 to Plane 2. U3: The line length is drawn perpendicular from Point 1 to Plane 3. U4: The length of point 1 to GO. * p<0.05).

	Class1			Class2			Class3		
	9-13	14-18	p	9-13	14-18	p	9-13	14-18	p
U1	3.58±2.19	5.23±2.54	**<0.001***	3.63±2.59	4.37±2.44	**0.026***	5.03±2.87	5.78±2.7	0.122
U2	13.73±2.14	13.46±1.84	0.491	14.51±2.24	13.93±2.12	0.071	14.15±2.07	13.84±2.07	0.109
U3	12.89±1.28	13.59±1.47	**<0.001***	13.03±1.27	13.61±1.70	**0.033***	12.62±1.18	13.68±1.63	**<0.001***
U4	23.66±2.30	26.26±3.24	**<0.001***	23.86±2.26	25.20±3.27	**<0.001***	22.65±2.75	26.25±2.86	**<0.001***

Table 3. Correlation of parameters with age (U1: The line length is drawn perpendicular from Point 1 to Plane 1. U2: The line length is drawn perpendicular from Point 1 to Plane 2. U3: The line length is drawn perpendicular from Point 1 to Plane 3. U4: The length of point 1 to GO. * p<0.05).

		U1	U2	U3	U4
Age	r	0.196	-0.086	0.298	0.407
	p	**<0.001***	**0.027***	**<0.001***	**<0.001***

Table 4. Difference of parameters according to malocclusion classes (U1: The line length is drawn perpendicular from Point 1 to Plane 1. U2: The line length is drawn perpendicular from Point 1 to Plane 2. U3: The line length is drawn perpendicular from Point 1 to Plane 3. U4: The length of point 1 to GO. * p<0.05).

PARAMETERS	Class1	Class2	Class3	*p*
U1	4.55±2.53	4.10±2.51	5.43±2.81	<0.001*
U2	13.57±1.97	14.14±2.17	13.98±2.07	0.005*
U3	13.30±1.43	13.40±1.58	13.19±1.53	0.370
U4	25.19±3.16	24.72±3.01	24.60±3.33	0.281

Table 5. Correlation table of the mandibular foramen (U1: The line length is drawn perpendicular from Point 1 to Plane 1. U2: The line length is drawn perpendicular from Point 1 to Plane 2. U3: The line length is drawn perpendicular from Point 1 to Plane 3. U4: The length of point 1 to GO. * p<0.05).

		U1	U2	U3	U4
U2	r	0.060	1		
	p	0.126	-		
U3	r	-0.077	0.039	1	
	p	**0.048***	0.318	-	
U4	r	0.289	0.143	0.319	1
	p	**<0.001***	**<0.001***	**<0.001***	-

In addition, a negative directional correlation was found between the distance of MF to OP and the posterior edge (p<0.048; r=-0.077). The correlation between the measurement values of MF is shown in Table 5.

DISCUSSION

In dentistry, IANB is used before routine or surgical procedures are planned on the mandible. 15-20% failure is observed in this frequently used anesthesia method. It is aimed to inject the anesthetic into the MF around to increase its success (Moore et al., 2007). Due to the diversity in the facial anatomies of the populations living in the world, there are many differences in the mandible and related structures (Gill et al., 2013). Since the mandible shows rapid growth and development until puberty, the position of MF changes in children aged 8-18 years (Paryab et al., 2015; Apaydın, 2020). Therefore, to obtain adequate and safe anesthesia in the mandible, it is necessary to know well the location of the MF according to race and age.

Very few studies reveal MF's position on pediatric and adult patients with malocclusion (Park et al., 2015; Paryab et al., 2015). Although there have been studies on the location of MF in children belonging to Turkish people (Apaydın, 2020), there have not been any studies in pediatric patients with malocclusion. Therefore, in this study, the position of the MF according to the classification of malocclusion in the PR of children divided into different age groups of developmental age was evaluated.

The panoramic radiography technique allows the mandible and surrounding anatomical structures to be visible on a single film with a low radiation dose. This imaging method is often preferred in dentistry for diagnosing the disease and post-treatment evaluation (Corbet et al., 2009). According to the PR, computed tomography, which provides three-dimensional imaging and realistic measurement results, has a high radiation dose, so its use in pediatric patients is limited. Therefore, in the methodology of our study, PR was used, which is the most frequently used in practice and has a low radiation rate.

It has been reported that there is symmetry between right and left MF in patients who do not have malocclusions (Tsai, 2004; Shukla et al., 2018). On the contrary, some studies report asymmetry (Krishnamurthy et al., 2017; Açıkgöz, 2020). It was reported that there was a significant difference in the distance of the MF to the anterior edge of the ramus of the mandible compared to lateralization in computed tomography images of patients aged 9-18 and 19-71 years belonging to the Turkish population. Still, no difference was detected in other data (Fındık et al., 2014). In this study, a significant difference was observed in the anterior edge of the ramus of the mandible in patients with Class 1 and Class 2 malocclusion, and the distance measurements between the GO compared to lateralization ($p<0.05$). In Class 3 malocclusion, there was no difference decisively between right and left ($p<0.05$). Since the difference between the right and left in the Class 1 and 2 malocclusion group was less than 0.35 mm, it was assumed that it would not cause failure of IANB in patients.

The literature has reported that the values measured in boys are higher than in girls (Açıkgöz, 2020). In children of developmental age, on the other hand, higher values were found in girls because girls enter puberty earlier than boys (Movahhed et al., 2011). In addition, some studies report no difference according to gender (Shukla et al., 2018; Feuerstein et al., 2020; Apaydın, 2020; Akman et al., 2021). In the conical beam computed tomography (CBCT) image of 100 patients aged 18-31 years with skeletal Class I, II, and III malocclusions, there is no significant difference in Class 1 and Class 2 malocclusion in patients according to gender. Still, it was found that the distance of MF to the anterior edge of the ramus of the mandible was significantly higher in male patients with Class 3 malocclusion compared to girls (Park et al., 2015). In our study, similar to the results of Park et al. (2015), there was no difference in Class 1 and Class 2 malocclusion according to gender, while all measurements except the distance to the OP in boys with Class 3 malocclusion were higher than in girls and showed a significant difference ($p<0.05$). We believe detecting MF higher than OP in girls with Class 3 malocclusion than in boys is an important finding that should be considered in increasing the success of anesthesia.

One of the essential anatomical signs used to determine the needle insertion location in IANB is OP. OP is used in the injection made for IANB in the clinic (Movahhed et al., 2011). In the study conducted in adults, a significant difference was found between the skeletal class malocclusion classes and the distance of MF to the OP. MF was higher in the Class 3 malocclusion group than in other groups (Park et al., 2015). In this study, MF was detected above all age groups and malocclusion classes, and a significant difference was observed between malocclusion classes consistent with existing literature ($p<0.05$). The distance between MF and OP was found to be the lowest in the Class 2 malocclusion group and the highest in the Class 3 malocclusion group. We believe that the position of MF relative to OP in children with Class 3 malocclusion is higher than in other classes due to the excessive development of the mandible or the more advanced position of the mandible or since the molar teeth do not keep up with growth and development and remain stable, the OP remains low.

The distance to the OP showed a significant difference between the age groups in all malocclusion classes ($p<0.05$). MF was found to be 4.01 ± 2.59 mm above OP in the 9-13 age group and 5.05 ± 2.60 mm above OP in the 14-18 age group without distinction of malocclusion class. There was a difference of 0.75 mm between the age groups in Class 2 and 3 malocclusions and 1.65 mm in Class 1 malocclusion. Increasing the distance of MF to OP with increasing age indicates an increase in the size of the ramus of the mandible in the upward direction. In many studies, it has been reported that MF changes in the upward course with increasing age, similar to our study (Hwang et al., 1990; Movahhed et al., 2011; Paryab et al., 2015; Shukla et al., 2018). In light of our results, similar to the literature studies, determining the injection site in IANB by taking into account the malocclusion classes and the ages of the patients will help provide adequate anesthesia. Although MF was detected above OP at a rate of 95.45% in our study, it was observed at the OP level at 2.88% and below OP at 1.67%. This difference we detected was thought to be because pediatric patients with mixed dentition periods had canine and molar tooth eruptions at different times.

Studies evaluating the AP position of MF in children reported that the distance to the anterior increased with age, and MF shifted to the posterior (Tsai, 2004; Pereira et al., 2013; Temür et al., 2022). In addition to the studies that report that MF is at the midpoint of the ramus, there are no changes in its age-related position. A study says that MF is in the inferoanterior in children (Hwang et al., 1990). The results are different because the study method, race, and age groups differ. In this study, it was found that the distance of MF to the posterior showed a positive correlation ($p<0.001$; r: +0.298) with age, and the distance of MF to the anterior showed a negative correlation ($p<0.02$; r: -0.086). A significant difference was found between the distance of the MF to the posterior edge and the age groups in all malocclusion classes. Besides, with the increase in age, it was seen that MF approached the middle point from the posterior edge. As a result of the age-related growth and development of the mandible, the distance between GO and MF increases due to MF's change of direction in the upward route (Shukla et al., 2018; Apaydın, 2020). In our study, the MF and GO distance significantly differed between age groups in malocclusion classes ($p<0.05$). We think that the distance between MF and GO shows a positive correlation with age due to the growth of the ramus of the mandible in the vertical direction and the increase in bone in the base of the mandible.

The study was conducted on a limited number of people who applied to the hospital for various reasons. In addition, the change in the OP due to the difference in eruption times of the canine and molar teeth, which form the OP, shows the limitation of this study. Therefore, further clinical studies with larger samples have to be conducted to determine the MF's location.

The position of the MF showed statistically significant differences in malocclusion classes and between age groups. It was seen that the MF was positioned in the upward direction parallel to the age increase and approached the midpoint of the ramus of the mandible from the posterior.

We detected MF 4.55 mm above the OP in Class 1 malocclusion, 4.10 mm in Class 2 malocclusion and 5.43 mm in Class 3 malocclusion. We believe that MF, especially in Class 3 malocclusion, being positioned higher than OP compared to other classes and showing a gender difference, will be a guideline for clinicians to minimize mistakes in providing effective and safe IANB in pediatric patients with malocclusion.

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Ethical Approval

This study was approved by the Necmettin Erbakan University, Faculty of Medicine, Non-Pharmaceutical and Medical Device Research Ethics Committee (Number: 14567952-050/673, decision number 2020/2497).

Authors contributions

Keskin A and Çiçekcibaşı AE designed the study, Keskin A and Mağat G performed the literature search and analysis, Keskin A wrote the manuscript in consultation with Çiçekcibaşı AE and Açar G.

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