RESEARCH

# Morphological and Morphometric Analysis of the Palatinal Groove, Crest and Bridge Formation Via Cone-Beam Computed Tomography

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**ABSTRACT**

**Morphological and Morphometric Analysis of the Palatinal Groove, Crest and Bridge Formation Via Cone-Beam Computed Tomography**

**Background:** The study aims to provide information on the location and morphology of the greater palatine groove, crest, and bridge in the hard palate and to improve awareness of these structures.

**Methods:** Two hundred cone beam computed tomography (CBCT) images were randomly selected and the existence of the groove/crest/bridge structures was evaluated in the upper first and second molar regions, regardless of dental situations (dentate or edentulous). The grooves were classified as flat (<1.5 mm), shallow (from 1.5 to 3 mm), and deep (> 3 mm). The presence and types of groove were recorded. All data were assessed according to different age groups and sex.

**Results:** Of the 200 images evaluated, 163 individuals (81.5%) had at least one groove and only 37 (18.5%) had no groove. A total of 737 grooves were detected and the mean depth of the grooves was 2.19±1 mm. The frequency of grooves was significantly higher in dentate regions ($p<0.05$). In the first and second molar regions, 185 sites (46.25%) and 231 sites (57.75%) had at least one groove, respectively. The most common type was shallow groove (53.18%, 392/737). The higher mean values of groove depth were in the 61-70 and 71-86 years' age groups.

**Conclusion:** Palatal groove is not a rare anatomic condition. Physicians should be aware of this structure to prevent damage to the neurovascular structures contained in grooves during surgical procedures in related areas.

**KEYWORDS**

**Anatomy; Cone Beam Computed Tomography; Hard Palate**

**ÖZ**

**Palatinal Oluk, Sırt ve Köprü Formasyonlarının Konik Işınlı Bilgisayarlı Tomografi Yoluyla Morfolojik ve Morfometrik Analizi**

**Amaç:** Posterior maksillayı içeren dental işlemler öncesinde sert damakta bulunabilecek büyük palatin oluk, sırt ve köprü yapılarının yeri ve morfolojisi hakkında bilgi sahibi olmaktır.

**Gereç ve Yöntemler:** Rastgele seçilen 200 konik ışınlı bilgisayarlı tomografi görüntüsü oluk / sırt / köprü yapıların varlığı, dental durumuna bakılmaksızın maksiller 1. ve 2. molar bölgede ayrı ayrı taranmıştır. Mevcut oluklar düz (<1.5 mm), sığ (1.5 ila 3 mm) ve derin (> 3 mm) olarak sınıflandırılmıştır. Ayrıca veriler farklı yaş gruplarına ayrılarak oluk varlığı ve türleri açısından değerlendirilmiştir.

**Bulgular:** Değerlendirilen 200 hastanın 163'ünde (% 81.5) en az bir oluk vardı ve hastaların sadece 37'sinde (% 18.5) hiç oluk yoktu. Tespit edilen toplam 737 oluğun ortalama derinliği 2.19 ± 1 mm idi. Oluklar dişli alanlara göre dişsiz bölgelerde önemli ölçüde daha fazla idi($p <0.05$). 1. ve 2. molar bölgelerinde sırasıyla 185 yer (%46.25) ve 231 yer (%57.75) en az bir oluğa sahipti. En yaygın oluk tipi sığ olarak bulundu. En yüksek ortalama oluk derinliği değerleri 61-70 ve 71-86 yaş gruplarındaydı.

**Sonuç:** Palatal oluk nadir görülen bir anatomik durum değildir. Bu bölgedeki cerrahi işlemler sırasında olukların içerdiği nörovasküler yapıların zarar görmemesi için klinisyenler bu yapının farkında olmalıdır.

**ANAHTAR KELİMELER**

**Anatomi; Konik Işınlı Bilgisayarlı Tomografi; Sert Damak**

## INTRODUCTION

The maxillary nerve is a branch of the trigeminal nerve and carries only sensitive sensory fibers. It innervates the middle part of the face, lower eyelids, the sides of the nose, the skin of the upper lips and the nasopharynx, maxillary sinus, tonsils, soft and hard palate, upper jaw teeth and gingiva. After the maxillary nerve emerges from the foramen rotundum, it gives off branches of the palatine nerve within the pterygopalatine fossa. The palatine nerve, which passes through the greater palatine canal and opens into the hard palate via the greater palatine foramen, extends to the posterior of the incisors and provides sensory innervation of the palate.

At the same time, accompanying vessels of the same name supply the mucous membrane of the hard palate, mainly the palatal glands and the palatal gingiva as far anteriorly as the maxillary canines.[1-3] Some authors stated that there were grooves on the hard palate adjacent to the greater palatine neurovascular bundle course and at the level of the first and second molar teeth regions and crests and bridges adjacent to these grooves. The authors cautioned that it was important not to be confused with other possible pathologies and to define these anatomic structures in terms of surgical procedures involving this region.[4] Cone beam computed tomography (CBCT) is often used as a preferred method in the field of dentistry for diagnosis and treatment planning because it provides

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three-dimensional imaging of the anatomy of the bone in the maxillofacial region with lower radiation, less cost, and higher resolution compared with computed tomography (CT).[5] It is very important to define these structures among surgical procedures involving the palatinal region because they can cause anesthesia failure in surgical procedures, prolonged bleeding, and neurosensorial changes; detailed evaluation with CBCT is very important.[4,6]

The aim of our retrospective archive study was to evaluate the presence of this defined groove, crest, and bridge separately for dentate and edentulous status and to gain information about the palatinal morphology of the maxilla.

## MATERIAL AND METHODS

### Data Selection

This retrospective study was conducted using data obtained from patients in the Oral and Maxillofacial Radiology Department of Recep Tayyip Erdoğan University, Faculty of Dentistry. The study was approved by the Ethics Committee of Recep Tayyip Erdoğan University, Faculty of Medicine (approval number 2021/55).

This study consisted of 200 randomly selected patients (98 females and 102 males) aged 18-86 years who had bilateral maxillary region CBCT images recorded because of dental diagnosis or treatment planning between 2017 and 2020. The patients' data were evaluated, retrospectively. All CBCT images were acquired using a Planmeca ProMax 3D Classic (Planmeca Promax 3D; Planmeca Oy; Helsinki, Finland) using the following parameters: 90 kV, 4-10 mA, 200 $\mu$m voxel size. The acquisition process was performed by an experienced oral radiologist according to the manufacturer's recommended protocol. The measurements and evaluations were performed using Planmeca Romexis 4.6.2.R software (PLANMECA Romexis, Helsinki, Finland).

### Eligibility Criteria

Inclusion criteria were high-quality CBCT images containing the entire maxillary arch. The presence of bone graft; the presence of metallic artifacts that could negatively influence the diagnostic quality; the presence of odontogenic/non-odontogenic cysts, odontogenic/non-odontogenic tumors, lesions that affected the cortical bone or cause perforation, surgery history at the relevant area or traumatic injury at the maxillary arch cases were excluded.

### Evaluation Of Groove, Bridge And Crest

Scans were evaluated by an oral and maxillofacial radiologist who had 11 years' experience (T.E.K). The presence of groove/bridge/crest in the first and second molar regions and dentate status was analyzed. Also, the age and sex of the patients in the study group were recorded. A line was drawn between the anterior nasal recorded. A line was drawn between the anterior nasal spine (ANS) and posterior nasal spine (PNS) on the sagittal plane, and this line was made parallel to the horizontal plane. The nasal cavity floor (NCF), was also positioned parallel to the axial plane. Thus standardization was achieved to evaluate the maxillary position of each patient. Grooves, crests, and bridging were evaluated if present, counted and recorded (**Figure 1** and **Figure 2**).

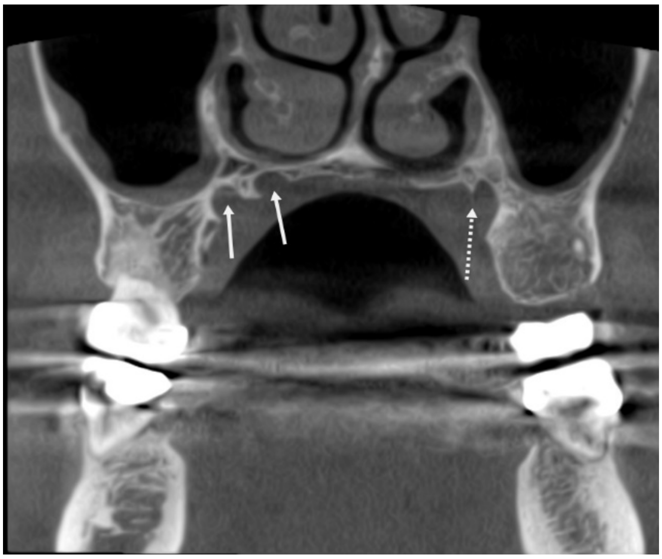

**Figure 1**

Palatal grooves (straight lines), crest formation (dashed line) present on the coronal slice of the CBCT.

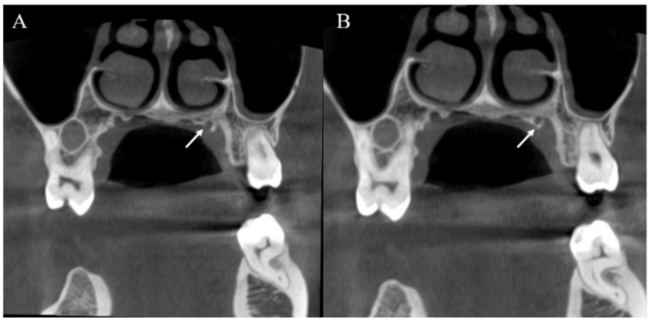


**Figure 2**

A. Palatal groove formation. B. Bridge formation formed the opening side of the groove.

According to the classification made by Miwa et al.[6] by measuring the grooves on the coronal sections, they were classified as flat (<1.5 mm), shallow (from 1.5 to 3 mm), and deep (> 3 mm) (**Figure 3**).

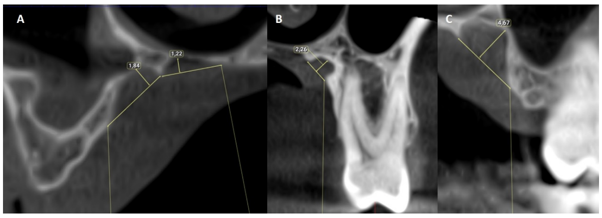


**Figure 3**

The measurements show the three types of groove in the molar region. Flat Groove (<1.5 mm); Shallow Groove (from 1.5 to 3 mm); Deep Groove (> 3 mm). A. Two different types of groove formation are presented with a crest. The groove structure close to the midline is flat type, the other is shallow type. B. Shallow groove type. C. Deep groove type.

### Statistical Analysis

The statistical analyses were performed using the IBM SPSS 8 version 23 (SPSS Inc., Chicago, IL, USA) with a level of significance of 5% ($p<0.05$). The kappa coefficient was used for the intra-observer correlation coefficient, for this purpose, 20% of random cases were measured again 2 weeks later. Descriptive analysis was performed for each variable of the first and second molars region. The Chi-square test was used to compare groove, crest, and bridge occurrences between the groups. Descriptive analysis was performed for the age of patients and deep grooves. One-way analysis of variance (ANOVA) and the Kruskal-Wallis H test were used to compare groove measurements between the groups. Tukey's honestly significant difference (HSD) and Mann-Whitney U tests were used for pairwise comparisons.

## RESULTS

Regarding the intra-observer reliability, the weighted Kappa coefficients represented an excellent agreement ($\kappa=0.872$).[7]

A total of 200 patients (102 males, 98 females) were investigated and the mean age for the study group was 46.05±15.46 years. The mean age for the females and males were 46.22±14.45 years and 45.89±15.88 years, respectively. One hundred sixty-three (81.5%) of 200 patients had at least one groove and only 37 (18.5%) had no groove. One hundred forty of the patients had bilateral grooves, while in 23 cases, the groove was unilateral (11 cases on the right side and 12 cases on the left side). A total of 800 different areas (right/left, first/second molars) were investigated and 416 had at least one groove formation. A total of 737 grooves were detected and the mean depth of the grooves was 2.19±1 mm. The distribution of groove types and the minimum, maximum, and mean depths are presented in **Table 1**.

**Table 1.**

**The results of measuring the groove depths (in mm) according to groove types.**

| Groove Type | n | Minimum | Maximum | Mean | Standard Deviation |
|---|---|---|---|---|---|
| Flat | 199 | 0.26 | 1.50 | 1.08 | 0.26 |
| Shallow | 392 | 1.52 | 3.00 | 2.17 | 0.44 |
| Deep | 146 | 3.05 | 6.00 | 3.73 | 0.63 |
| **Total** | 737 | 0.26 | 6.00 | 2.19 | 1.00 |

*n: number of grooves*

According to the results, grooves were seen on dentate areas significantly more than the edentulous areas ($p<0.05$). However, there was no significant difference between the groove type and the presence of tooth. In addition to these findings, there was no significant relationship between the presence of tooth and bridging. Also, there was no significant difference between the sexes according to the presence of grooves ($p=0.383$) and groove types ($p=0.409$).

A total of 800 first and second molar areas were investigated and 185 (46.25%) and 231 (57.75%) of the areas had at least one groove, respectively. The difference in prevalence between the areas was statistically significant ($p=0.01$). The number of grooves, crests, and bridge structures according to sides, genders, and dental status are presented in **Table 2**. In the first molar region, the groove was present bilaterally in 77 cases while in 106 individuals, the grooves in the second molar region were bilateral.

**Table 2.**

**Distribution of groove, crest and bridge formation according to the sex, maxillary area, and presence of tooth.**

| | | | | Groove | | Crest | | Bridge | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | n/total | p value | n/total | p value | n/total | p value |
| Female | 1st molar area | Dentate | Right | 24/43 | 0.925 | 21/43 | 0.597 | 0/43 | 0.320 |
| | | | Left | 25/44 | | 19/44 | | 1/44 | |
| | | Edentulous | Right | 21/55 | 0.507 | 15/55 | 0.702 | 0/55 | N/A |
| | | | Left | 24/54 | | 13/54 | | 0/54 | |
| | 2nd molar area | Dentate | Right | 36/47 | 0.987 | 23/47 | 0.818 | 0/47 | 0.293 |
| | | | Left | 33/43 | | 20/43 | | 1/43 | |
| | | Edentulous | Right | 25/51 | 0.350 | 16/51 | 0.798 | 1/51 | 0.957 |
| | | | Left | 22/55 | | 16/55 | | 1/55 | |
| Male | 1st molar area | Dentate | Right | 26/45 | 0.289 | 18/45 | 0.575 | 1/45 | 0.337 |
| | | | Left | 19/41 | | 14/41 | | 0/41 | |
| | | Edentulous | Right | 21/57 | 0.645 | 16/57 | 0.394 | 1/57 | 0.299 |
| | | | Left | 25/61 | | 13/61 | | 0/61 | |
| | 2nd molar area | Dentate | Right | 34/50 | 0.643 | 25/50 | 0.479 | 1/50 | 0.873 |
| | | | Left | 29/40 | | 23/40 | | 1/40 | |
| | | Edentulous | Right | 21/52 | 0.305 | 17/52 | 0.894 | 0/52 | N/A |
| | | | Left | 31/62 | | 21/62 | | 0/62 | |

*Statistically significant differences ($p < 0.05$), n number of structure, N/A Not applicable*

The distribution of the total of 737 grooves according to different types and locations is outlined in **Table 3.**

**Table 3.**

**Distribution of groove types according to gender, maxillary area, and presence of tooth.**

| | | | | Flat Groove | Shallow Groove | Deep Groove |
|---|---|---|---|---|---|---|
| | | | | n | n | n |
| Female | 1st molar area | Dentate | Right | 18 | 28 | 2 |
| | | | Left | 21 | 25 | 2 |
| | | Edentulous | Right | 15 | 16 | 6 |
| | | | Left | 10 | 20 | 5 |
| | 2nd molar area | Dentate | Right | 12 | 31 | 14 |
| | | | Left | 11 | 24 | 16 |
| | | Edentulous | Right | 10 | 24 | 10 |
| | | | Left | 8 | 21 | 12 |
| Male | 1st molar area | Dentate | Right | 20 | 26 | 3 |
| | | | Left | 11 | 22 | 5 |
| | | Edentulous | Right | 11 | 22 | 5 |
| | | | Left | 17 | 22 | 6 |
| | 2nd molar area | Dentate | Right | 9 | 32 | 20 |
| | | | Left | 11 | 25 | 18 |
| | | Edentulous | Right | 9 | 22 | 8 |
| | | | Left | 6 | 32 | 14 |

*n number of structure, Flat Groove (<1.5 mm); Shallow Groove (from 1.5 to 3 mm); Deep Groove (> 3 mm)*

Results on the groove depth measurements according to age groups are presented in **Table 4**.

**Table 4.**

**The results of measuring the groove depths (in mm) according to age groups.**

| Age groups | n | Minimum | Maximum | Mean | Standard Deviation |
|---|---|---|---|---|---|
| 18-30 | 161 | 0.60 | 6.00 | 2.23 | 1.05 |
| 31-40 | 157 | 0.60 | 5.94 | 2.22 | 0.97 |
| 41-50 | 222 | 0.26 | 5.81 | 2.08 | 0.95 |
| 51-60 | 125 | 0.52 | 5.28 | 2.07 | 0.92 |
| 61-70 | 56 | 0.60 | 5.22 | 2.53 | 1.02 |
| 71-86 | 16 | 0.80 | 5.56 | 2.59 | 1.45 |
| **Total** | 737 | 0.26 | 6.00 | 2.19 | 1.00 |

*n: number of grooves*

The mean groove depth was greater in the 61-70 years than individuals under 60 years of age (**Table 5**).

**Table 5.**

**The measurements (mean groove depth) in Table 4 were compared according to age groups.**

| | Age groups | n | p value | Compared groups |
|---|---|---|---|---|
| **#1** | 18-30 | 161 | 0.027* | 1-5 |
| **#2** | 31-40 | 157 | 0.042* | 2-5 |
| **#3** | 41-50 | 222 | 0.001* | 3-5 |
| **#4** | 51-60 | 125 | 0.003* | 4-5 |
| **#5** | 61-70 | 56 | N/A | - |
| **#6** | 71-86 | 16 | 0.720 | 6-5 |
| | **Total** | 737 | | |

**Statistically significant differences ($p < 0.05$), n number of grooves, N/A Not applicable, #1–#6 correspond to age groups*

Statistically significant differences were seen between the presence of tooth and crest formation ($p<0.001$). There were more crest formations in the dentate areas (46.18%) than in the edentulous areas (28.41%). The prevalence of the crest formation in the first and second molar areas was 32.25% and 40.25%, respectively, which was statistically significantly different ($p=0.019$). No significant difference was seen between the sexes for the crest formation ($p=0.895$).

There was no significant relationship between the region and the presence of bridging. Likewise, statistically, no significant difference was determined between the sexes and the presence of bridging ($p=0.955$).

## DISCUSSION

Palatine neurovascular structures supply and innervate the relevant region by run-through on bony structures such as grooves, crests, and bridges on the hard palate. For surgical procedures that include this anatomic structure, it is extremely important to evaluate the morphologic structure of this region. These surgical procedures include planning dimensions and harvesting connective tissue grafts from the palate, orthodontic mini-implant placement, donor sites for minimal autogenous bone grafts, impacted tooth extraction or tumor/cyst enucleation.[6,8-11] For example, it has been reported that there are sensory changes after grafts are taken from the palatal region[12] and complications such as prolonged bleeding after placing palatal implants for orthodontic purposes.[13] It is important to evaluate all the anatomic features of the relevant region using CBCT to prevent complications such as unexpected bleeding before administering anesthesia for dental surgical procedures planned in this region.[10] When Monsour and Huang evaluated the presence of palatal grooves for the first and second molar regions separately, they stated that there was no palatal groove in 60%, one groove in 34%, and two grooves in 6% in the first molar region.

In the second molar region, these rates were reported as 72%, 26%, and 2%, respectively. Images with first and second molar deficiencies in their scans were excluded from the study.[10] Ling et al.[14] excluded patients with first and second molar deficiencies in their study on CBCT, similar to other work.[10] No groove, one groove, and two grooves in the first molar region are found at rates of 74%, 25%, and 1% for females and 77%, 22%, and 1% for males, respectively. In the second molar region, these rates are 63%, 36%, and 1% for females, and 60%, 37%, and 3% for males, respectively.[14] Also Ling et al. found that the probability of a groove in the second molar region was higher than in the first molar region.[14] In our study 81.5% of the patients had at least one groove in any of the areas. For the first molar and second molar areas, the prevalence of at least one groove was 46.25% and 57.75%, respectively. Contrary to Monsour and Huang,[10] and in accordance with Ling et al.,[14] we found a higher prevalence at the second molar area. When only dentate patients' data evaluated, groove(s) were detected in 54.33% of the first molar and 64.77% of the second molar areas. The course of the palatine nerve starts from the greater palatine foramen at the palate area and reaches the anterior region of the palate. Accordingly, the groove formation may be more frequent in this region because the root of the neurovascular bundle is thicker at the greater palatine foramen region. The difference between results may be caused by ethnic diversity of populations in the studies.[10,14] As other researchers have stated,[10,14] in cases where the groove is not seen, the palatinal neurovascular bundle should be evaluated carefully because it may progress just below the soft tissue.

Miwa et al.[6] evaluated groove structures in their study as follows: flat groove (dentate: 31.6%, 31/98; edentulous: 15.2%, 7/46), shallow groove (dentate: 20.4%, 20/98; edentulous: 34.8%, 16/46) and deep groove (dentate: 48.0%, 47/98; edentulous: 50.0%, 23/46) and the deep grooves were observed most frequently. They claimed that the reason for the frequent deep groove structure observation in the edentulous group might be due to the remodeling of the palate bone by forming a socket-like protuberance after tooth loss.[6] In our study, we found more groove formations in the dentate areas. In contrast to Miwa et al.'s claim,[6] we believe that the groove formation present in the early ages and with the extraction of teeth, and the increasing rate of resorption of the alveolar socket area may reduce the groove numbers significantly. Another reason behind this may be derived from the use of removable prostheses, which may erode the crest formations with the direct pressure and also possible morphologic/remodeling changes of the palate due to direct pressure of prostheses. A final theory is the relocation of the chewing center with the loss of teeth because patients with tooth loss start to chew with their gums/alveolar bone and also the palatal slope.

In our study, the rates of these were found as flat grooves (dentate: 27.83%, 113/406, edentulous: 25.98%, 86/331), shallow grooves (dentate: 52.46%, 213/406, edentulous: 54.08%, 179/331) and deep grooves (dentate: 19.70%, 80/406, edentulous: 19.94%, 66/331). The differences between results may be caused by the age ranges; Miwa et al.'s [6] groups' age ranged between 59-94 years, whereas our study group comprised patients aged between 18-86 years. The groove types may have been seen differently because the age range in our study was younger than in Miwa et al.'s study.[6] Other reasons for this may be the ethnic diversity or sample size can be affected the results. Also Miwa et al used cadavers.[6]

In the study conducted by Ling et al.,[14] it was stated that crests and grooves differed significantly between the right and left sides of each tooth area. In this study, no significant difference in the presence of the groove between the left and right sides. Ling et al.[14] found no correlation between sex and the presence of grooves/crests,[14] also there was no relationship between sex and presence of grooves/groove types and crests in our study.

Monsour and Huang stated that they had never seen bridging.[10] Ling et al.[14] also reported that bridging was not observed in their study. By contrast, we found eight bridge structures in our search. Ling et al.[14] reported that the reason why there was no bridging in the CBCT images was that the bridge was a fibrous band connecting bilateral incomplete canals. This difference between studies could be explained by morphologic features that vary among different populations. In addition, it is emphasized that it is important to palpate and radiologically evaluate this area to prevent complications during and after local anesthesia and periodontal surgery due to the presence of crests.[4,14]

The limitations of this study are the observational nature of the method and the missing data for the period of tooth loss.

The authors believe that this study will make a great contribution to the literature because the existence of grooves/crests and bridging has not been evaluated separately for both first and second molar regions and also according to the tooth presence in any previous studies.

## Conclusion

It is essential to know the anatomy of this region for performing palatinal regional anesthesia and to facilitate surgical management in the hard palate (orthodontic implant, advanced periodontal surgery) and also not to be confused by the presence of another pathology.

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## Funding

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## Conflict of Interest

The authors declare that they have no conflict of interest.

## Ethics Approval

The study design was approved by the Ethics Committee of the Recep Tayyip Erdoğan University Faculty of Medicine (2021/55).

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