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

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 greater palatine neurovascular bundle and at 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 palatine glands and the palatal gingiva as far anteriorly as the maxillary canines. Some authors stated that there were grooves on the hard palate adjacent to the greater palatine neurovascular bundle 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. 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...
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 µm 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 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).

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

<table>
<thead>
<tr>
<th>Groove Type</th>
<th>n</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat</td>
<td>199</td>
<td>0.26</td>
<td>1.50</td>
<td>1.08</td>
<td>0.26</td>
</tr>
<tr>
<td>Shallow</td>
<td>392</td>
<td>1.52</td>
<td>3.00</td>
<td>2.17</td>
<td>0.44</td>
</tr>
<tr>
<td>Deep</td>
<td>146</td>
<td>3.05</td>
<td>6.00</td>
<td>3.73</td>
<td>0.63</td>
</tr>
<tr>
<td>Total</td>
<td>737</td>
<td>0.26</td>
<td>6.00</td>
<td>2.19</td>
<td>1.00</td>
</tr>
</tbody>
</table>

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 sexes, genders, and dental status are presented in Table 2. In the first molar region, the groove was present bilaterally in 31/62 (50%), while in 17/52 (36.5%) of the second molar areas. There was no significant difference between the sexes according to the presence of grooves (p=0.409).

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

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.

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Flat Groove</th>
<th>Shallow Groove</th>
<th>Deep Groove</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Female</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st molar area</td>
<td>24</td>
<td>12</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Edentulous</td>
<td>18</td>
<td>15</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>2nd molar area</td>
<td>16</td>
<td>8</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Edentulous</td>
<td>12</td>
<td>10</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td><strong>Male</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st molar area</td>
<td>32</td>
<td>20</td>
<td>17</td>
<td>5</td>
</tr>
<tr>
<td>Dentate</td>
<td>20</td>
<td>11</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>Edentulous</td>
<td>22</td>
<td>17</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>2nd molar area</td>
<td>24</td>
<td>11</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Dentate</td>
<td>20</td>
<td>11</td>
<td>11</td>
<td>8</td>
</tr>
</tbody>
</table>

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.

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

n: number of grooves

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.5,8,11 For example, it has been reported that there are sensory changes after grafts are taken from the palatal region12 and it has been reported that there are sensory changes after grafts are taken from the palatal region12 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 or sample size can be affected the results. Also Miwa et al used cadavers.6

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.’s6 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.
Acknowledgements
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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).
REFERENCES