Ossification of the pterygospinous and pterygoalar ligaments and their clinical relevance

Damir Čirić¹, Eldan Kapur², Elvira Talović²

¹Department of Surgery, High Medical School, University of Bihać, Bihać, Bosnia and Herzegovina
²Department of Anatomy, Medical Faculty, University of Sarajevo, Sarajevo, Bosnia and Herzegovina

Submitted: 6.3.2017. / Accepted: 27.5.2017.

ABSTRACT

Objectives: The objective of this research was to determine the morphometric characteristics of lateral pterygoid plate, incidence and detailed anatomy of pterygospinous and pterygoalar bony bridges and their correlation with oval foramen.

Material and methods: The anatomical variations of lateral pterygoid plate were studied at 100 dried human skulls (50 males, 50 females), bilaterally. The statistical analyses were conducted according to the side of cranium, gender and age.

Results: The presence of complete pterygospinous foramen was found in 4% and presence of pterygoalar foramen in 15% of cases. The significant difference of incomplete pterygospinous bony bridges incidence according to gender has not been confirmed. However, it has been established higher frequency of complete pterygospinous and pterygoalar foramen, as well as incomplete pterygoalar foramen in men compared with female skulls. Higher frequency of pterygospinous foramen was noticed on male skulls in comparing to female skulls with a ratio 3/1. The pterygoalar foramen had left-sided predominance, independently to gender. We found a significantly higher frequency in presence of complete ossified pterygoalar bony bridges on the left side (12% cases), comparing to right side (3% cases) regardless to gender.

Conclusion: Ossifications of pterygospinous and pterygoalar ligaments aren’t as rare as previously thought. While interpreting radiological images and performing procedures that require access to foramen ovale, infratemporal fossa and parapharyngeal region, variable ossified formations at lateral plate’s posterior border of pterygoid process should be kept in mind.

Key words: Lateral pterygoid plate, pterygospinous and pterygoalar bony bridges, the pterygospinous and pterygoalar foramen

INTRODUCTION

The human body, as well as its organs and tissues show variability in size, form and structure. During the past centuries, dissection of mammals and human beings was the only way of cognition of this spectrum of variability. Although, development of wide spectrum of radiological and surgical procedures has enabled in vivo detection of anatomical variation, there is still great significance of dissection [1]. Accurate knowledge of variability in human morphology is important to improve interpretation of radiological findings, to insure safer performance of invasive diagnostic and therapeutic procedures, as well as better understanding of specific clinical state of the patient. Some parts of human body show greater variability comparing to others. Ligaments of sphenoid bone: pterygospinous, pterygoalar, interclinoid and caroticoclinoid show great variability according to complete and incomplete ossification. Ossification of this ligaments are of great significance in maxillofacial-, neuro- and oral-surgery, neurology, otorhinolaryngology and radiology in domain of invasive, diagnostic and therapeutic procedures, as well as in interpretation of radiological findings and a wide range of different clinical states [eg. trigeminal neuralgia].

Lateral lamina of pterygoid process is thin and wide bony plate, whose medial side is part of pterygoid fossa and lateral side part of medial wall of infratemporal fossa. Posterior border of lateral pterygoid plate has irregular shape and from its middle or distal part stretches the ligament toward well developed spine on inferior surface of greater wing of sphenoid bone called sphenoidal spine or spina angulare, and this ligament is called pterygospinous ligament [2]. Ossification of this ligament produce bony bar which becomes part of a new formed foramen called pterygospinous foramen, or foramen of Civinini – named in honor of Filipo Civinini who in 1829 firstly described this variable foramen in human skull [3]. Ossified ligament makes a
inferior margin of pterygospinous foramen, its anterior margin is posterior margin of lateral plate and above is limited by inferior surface of external side of greater wing of sphenoid bone. Through pterygospinous foramen, who is localized just next to oval foramen, can pass medial pterygoid blood vessels and nerves, as well as some motor branches of mandibular nerve for masticator musculature. Kapur in 2000 suggest possibility of passing through pterygospinous foramen branches of medial meningeal artery on its way to medial pterygoid muscle [4]. Hyrtl in 1862 describes ossification of ligament which extends from spine localized on proximal third of posterior margin of lateral plate toward inconsistent well developed spine (but not sphenoid spine) on inferior surface of greater wing [5,6]. Complete ossification of this ligament results with creation of pterygoalar foramen, also called foramen craniophitico – buccinatorium or Hyrl’s foramen [7]. Medial from pterygoalar foramen passes by lingual nerve and inferior alveolar nerv and through foramen it self can pass motor branches of trigeminal nerve (branches for buccinator, lateral pterygoid and temporalis muscle), veins of pterygoid venous plexus and some arterioles.

According to position of oval foramen, pterygospinous and pterygoalar ossified ligaments can be found medial, across and lateral positioned. Peuker et al. 2001 suggested possibility of secondary - age progressing ossification, while Lang and Hetterich in 1983 represent case of pterygospinous ligament ossification in a 5 years old boy [8,9]. Based on insignificant incidence of age related ossification in most of performed studies, ossification of these ligaments are considered as phylogenetic remnants and that genetic factors have the biggest influence on development of ossification’s. Ossification of ligaments can cause nerve intrapment and result in a wide range of neurological deficit. Hai J et al. notes that cause of 20% of trigeminal neuralgia is due to nerve compression caused by bony structures [10]. Krmpotić – Nemanić et al. suggests possibility of trigeminal neuralgia due to compression caused by ossified ligaments [11]. Lingual nerve could be compressed by: 1) ossified pterygospinous or/and pterygoalar ligaments, 2.) extremely wide lateral pterygoid plate, 3.) muscle fibers of anterior part of lateral pterygoid muscle [12]. Approach to oval foramen due Gaserian ganglion block or rhizolysis, as well as to perform mandibular or maxillary nerve block could be more difficult or disabled due presence of this ossifications. [13,14,15].

While applying conductive anesthosa on mandibular nerve by lateral subzygomatic route, variable ossified formations at lateral plate’s posterior border of pterygoid process should be kept in mind. It is possible that a needle, at a depth of 35 mm, comes across incompletely or completely ossified pterygospinous and/or pterygoalar ligaments [4]. Obstruction while performing maxillary nerve block anesthesia could be caused by extremely large lateral pterygoid plate [16]. By coronoid approach to mandibular nerve and trigeminal ganglion ossified ligaments can be obstacle only in case of its lateral position in regard to oval foramen. However, by lateral sublabial endoscopic approach to oval foramen as in the case of some trigeminal nerve techniques even centrally (across oval foramen) positioned ossified pterygospinous and pterygoalar ligaments can represent an obstacle [17].

**Material and Methods**

The anatomical variations of lateral pterygoid plate of sphenoid bone were studied at 100 randomized selected, dried, macerated and degresed human skulls (50 males, 50 females) on both sides of the skull. All skulls are from people who habituated in the area of Bosnia and Herzegovina. The skulls were used from a collection of Department of anatomy, Medical Faculty, University of Sarajevo. Observed and measured were length and width of lateral pterygoid plate of sphenoid bone, complete and incomplete pterygospinous and pterygoalar ligaments, and its relations with oval foramen. The statistical analyses were conducted according to the side of cranium, gender, and age, using Microsoft Excel 2007, Biostat 2008 and MedCalc softwares, Pearson test, t-test of significance and ANOVAs test.

All measurements were performed by two researchers using a digital sliding caliper.

**Results**

Anthropometrical measurements were performed on 50 male and 50 female human skulls, that is 200 lateral plates of pterygoid process. Age of studied subjects ranged between 19 to 96 years, average age 56,34±18,85 years, without gender related statistically significant difference (p=0,929). The mean length of lateral pterygoid plates was 26,91±2,25 mm, male 28,31 ±2,32mm, female 25,49± 2.18 mm, with significantly greater length in men (p=0,0001). Mean width of lateral pterygoid plate was 11,89±3.035mm, minimum 5mm and maximum 23mm. Mean width of the plate in male was 12,84±3,395 mm and in female human skulls was 10,95±2,74mm. Lateral lamina of pterygoid process was significantly wider in men, comparing to women skulls (p=0,0006). On the right side of the skull were measured wider plates independently to gender. It was found 18 incompletely ossified pterygospinous ligament (Figure 1. and 2.) in 16 skulls (in 14 skulls unilateral, and in 2 bilateral). Incomplete ossification was found in 16% of cases. Gender related incomplete ossification incidence difference of pterygospinous ligament wasn’t established. However, there
is significantly higher incidence on the right side in both sexes (p=0.042).

Figure 1. Incomplete ossification of pterygospinous ligament in a female skull, premortem age of 37, right side.
LLPP – lateral lamina of pterygoid process; PsN – pterygospinous spine, SS – sphenoidal spine

Contact type of pterygospinous foramen was found in only one male skull, unilaterally.

Figure 2. Incomplete ossified pterygospinous ligament (male human skull, age 52, right side)
LLPP – lateral lamina of pterygoid process; PsN – pterygospinous spine, SS – sphenoidal spine

Pterygospinous foramen was found in 4% of cases with a male/female ratio 3/1, predominately right-sided (3/1). Mean diameter of pterygospinous foramen was 8.77±1.53mm. In 50% of cases pterygospinous foramen was located laterally from oval foramen, in 25% medially from it and in 25% pterygospinous bony bar went across a oval foramen. Incomplete ossification of pterygoalar ligament was stated in 20% of cases. From 20 skulls with present incomplete ossification in 18 ossification was unilateral and in 2 skulls bilateral.

Figure 3. Pterygosospinous foramen (male human skull, age od 47, right side)
pf – pterygosospinous foramen; fo – foramen ovale; pl – pterygospinal ligament – osiffied; llpp – lateral lamina of pterygoid process.

Incomplete ossification of pterygoalar ligament has male predominance, again in ratio 3/1 (15 male/5 female skulls). Right-sided predominance was present again.

Figure 4. Incomplete ossification of pterygoalar ligament in a female human skull, premortem age of 56, left side).
a – incompletly ossified pterygoalar ligament; b – lateral lamina of pterygoid process.

Pterygoalar foramen was found in 15% of cases (15 skulls, male/female ratio=9/6). Significantly higher complete ossification incidence was found in men ($\chi^2=1.515; p=0.0218$). Contrary to right sided predominance in size of lateral plate of pterygoid process and incidence of complete and incomplete pterygosospinous ligament ossification, as well as incomplete pterygoalar ligament ossification, pterygoalar foramen has left-sided predominance, independently to gender. Mean diameter of pterygoalar foramen was 3.46±1.26mm. Mean distance of pterygoalar ligament to oval foramen was 3.14±1.82mm. In 40% of cases pterygoalar fora-
Lateral lamina of the tongue, anesthesia of the lingual gums and of the tongue, loss of taste in the anterior two thirds of the tongue with numbness, hypoesthesia, or even anesthesia. Compression of the lingual nerve, is associated with neuralgia or paralysis of the innervated muscles, whereas compression of the sensory branches can provoke neuralgia or paraesthesia. Shaw suggested that traction or compression of cutaneous fibers of the mandibular nerve, due to bone overgrowth around the margins of the pterygospinous or pterygoalar foramen, could be responsible for a small proportion of cases of trigeminal nerve neuralgia’s [20]. Chronic progressive compression of the lingual nerve, due to slow bone deposition, may cause physical damage to the axons at the entrapment site, as well as to neighbouring segments of the nerve.

Peuker et al. observed an unusual course of the lingual nerve in an 82-year-old male cadaver, whereby entrapment of the nerve occurred between a widely ossified pterygospinous ligament and the medial pterygoid muscle [8]. Peker et al. observed entrapment of the mandibular nerve during its course through the pterygoalar ligament on the left side of the cadaver of a 70-year-old man [19]. Compression of sensory branches of the mandibular nerve by the masticatory muscles is a possible cause of neuropathology (neuralgia or paresthesia). The existence of a degenerated and wide lateral plate of the pterygoid process measuring laterally 24 mm to 32 mm was established [11]. The mean length of lateral pterygoid plates in this study was 26,91±2,25 mm with maximum length measured in male skull of 33 mm and significantly greater length in men. Mean width od lateral pterygoid plate was 11,89±3,035 mm, minimum 5 mm and maximum 23 mm, again with significantly greater width in men.


discussion

Anatomical variations of lateral pterygoid plate of sphenoid bone generate interest in morphological, anthropological and specially clinical circles. Lateral surface of lateral pterygoid plate forms a part of medial wall of the infratemporal fossa, which contains big and important neurovascular structures, and for surgeons is one of the most difficult approachable regions of the human body. Clinical significance of knowledge of anatomical variations of lateral pterygoid plate, as well as the ossified intrinsic sphenoid ligaments who originate from its posterior margin is in procedures of regional anaesthesia of trigeminal nerve or its two branches (mandibular and maxillary). It should be kept in mind that nerve compression with this structures could be cause of neuralgia’s or motor weakness. Piagkou et al. state possibility of mandibular nerve and its branches entrapment by totally or partially ossified pterygospinous and pterygoalar ligaments, extremely wide lateral pterygoid plate and the medial fibers of the lower belly of the lateral pterygoid muscle and the inner fibers of the medial pterygoid muscle [18]. Compression of the MN motor branches can lead to paresis or weakness in the innervated muscles, whereas compression of the sensory branches can provoke neuralgia or paraesthesia. Compression of the lingual nerve, is associated with numbness, hypoesthesia, or even anaesthesia of the tongue, loss of taste in the anterior two thirds of the tongue, anaesthesia of the lingual gums and chewing and speaking related pain [11]. Lateral lamina of pterygoid process is very important landmark while performing mandibular, maxillary or trigeminal nerve block, while extremely large lateral plate could impose problem and prevent us to perform adequate nerve block or disable surgical approach to para- and retro-pharyngeal space. Elongation of lateral pterygoid plate can cause lingual nerve entrapment resulting in attenuation of the afferent nerve impulses transmission from taste buds located on anterior two thirds of the tongue. Krmpotic-Nemanić et al. observed that the appearance of the large lateral lamina was in general unilateral. In a single case a large lateral lamina was found bilaterally. In five out of 100 examined dry adult skulls, the existence of a degenerated and wide lateral plate of the pterygoid process measuring laterally 24 mm to 32 mm was established [11]. The mean length of lateral pterygoid plates in this study was 26,91±2,25 mm with maximum length measured in male skull of 33 mm and significantly greater length in men. Mean width od lateral pterygoid plate was 11,89±3,035 mm, minimum 5 mm and maximum 23 mm, again with significantly greater width in men.

De Froe and Wagemaaar were the first to recognize the radiographically of the pterygoalar bar. In an anatomical study of European skulls, they observed the presence of the pterygospinous foramen in 5% of the cases studied [21]. A corresponding study of over 6000 sample skulls confirmed their results. In 1951, Chouke and Hodes found the pterygoalar bar in 7.05% of their 1234-patient sample (in 0.89% bilaterally) [22,23,24,25]. Lepp and Sandner reported that these osseous bridges were present in about 8%–10% of the population and that the pterygoalar ligament was ossified more often than the pterygospinous ligament [26]. Wood & Jones found incidence of pterygospinus ligation ossification in 8% of observed Hawaiin human
skulls [27]. Lang reported incidence of 12-13% ossified pterygospinous ligaments on population native to Africa, Peker et al. report incidence of ossification in 8.8% Anadolyan skulls [15]. Nayak et al. report occurrence of complete ossified pterygospinous ligament in 5.76% and incomplete ossification in 3.84% of cases [28]. Kapur et al. noted a lower frequency of pterygospinous foramen (1.31%) in Bosnian population [4]. In 1931 Jones emphasis racial and crosscultural variations in frequency of pterygospinous and pterygoalar ligament ossification, which was confirmed in further researches [27]. Peker found similarity of ossification frequency between Anadolians males, Italians, Caucasians Americans, Afro-Americans, but no similarity to Dutch and South African males. Moreover, the dissimilarities are greater among females of various ethnic populations [19]. Chouke reported a tendency for asymmetry in both genders, with preference for a unilateral occurrence on the left side [22,23]. By contrast, De Villiers found the pterygoalar bar more commonly located on the right side [29].

We found completely ossified pterygospinous ligament in 4% of cases, which is three times higher frequency comparing to those noted by RS Tubbs - 1.3%, two times higher frequency comparing to Civinini's result - 2.3% and Antonopoulou - 2%, approximately same frequency noted by Lepp and Sandler, two times lower frequency comparing to results represented by Peker and al. 8.8% and Rossa and al. 8.61% [3,19,30,31,32]. It was found mean diameter of pterygospinous foramen measuring 8.77±1.53mm, which is some bigger diameter comparing to diameter measured by Jansirani 7.5x7.7mm and smaller than values found by Galdames (10.63x7.37 mm) [33].

Table 1. Ossification frequency of pterygospinous and pterygoalar ligaments according to available study results

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Population/Sample</th>
<th>Demacerated skulls (DS)/Patient (P)</th>
<th>Pterygospinous ligament ossification (%)</th>
<th>Pterygoalar ligament ossification (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood</td>
<td>1931</td>
<td>Hawaii</td>
<td>DS</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Chouke</td>
<td>1949</td>
<td>Europe/ 6000</td>
<td>DS</td>
<td>-</td>
<td>7.22/14.79</td>
</tr>
<tr>
<td>Chouke &amp; Hodes</td>
<td>1951</td>
<td>USA/1234</td>
<td>DS</td>
<td>-</td>
<td>5.25/-</td>
</tr>
<tr>
<td>Primani &amp; Etter</td>
<td>1959</td>
<td>USA/ 250</td>
<td>DS</td>
<td>3/8</td>
<td>2.5</td>
</tr>
<tr>
<td>Tebo</td>
<td>1968</td>
<td>India/516</td>
<td>DS</td>
<td>3.9/33</td>
<td>-/-</td>
</tr>
<tr>
<td>Shaw</td>
<td>1993</td>
<td>545</td>
<td>DS</td>
<td>16.1/10.81</td>
<td>-/-</td>
</tr>
<tr>
<td>Kapur</td>
<td>2000</td>
<td>Bosnia and Herzegovina/ 305</td>
<td>DS</td>
<td>3.6/14.75</td>
<td>7.5/14.4</td>
</tr>
<tr>
<td>Peker</td>
<td>2002</td>
<td>Turkey/ 452</td>
<td>DS</td>
<td>8.8/7.5</td>
<td>-/-</td>
</tr>
<tr>
<td>Pinar</td>
<td>2004</td>
<td>Turkey/361</td>
<td>DS</td>
<td>4.63/9.7</td>
<td>1.1/4.98</td>
</tr>
<tr>
<td>Skrzat</td>
<td>2005</td>
<td>Poland/70</td>
<td>DS</td>
<td>-/-</td>
<td>7.1</td>
</tr>
<tr>
<td>Von Ludighausen</td>
<td>2006</td>
<td>Japan/100</td>
<td>DS</td>
<td>6/-</td>
<td>-/-</td>
</tr>
<tr>
<td>Das &amp; Paul</td>
<td>2007</td>
<td>India/50</td>
<td>DS</td>
<td>2/-</td>
<td>-/-</td>
</tr>
<tr>
<td>Nayak</td>
<td>2007</td>
<td>India/ 416</td>
<td>DS</td>
<td>5.76/3.84</td>
<td></td>
</tr>
<tr>
<td>Antonopoulou</td>
<td>2008</td>
<td>Greece/ 50</td>
<td>DS</td>
<td>2/25</td>
<td>2/-</td>
</tr>
<tr>
<td>Tubbs RS</td>
<td>2009</td>
<td>Australia /154</td>
<td>DS</td>
<td>0.64/0.64</td>
<td>0.64/0.64</td>
</tr>
<tr>
<td>Rosa RR</td>
<td>2010</td>
<td>Brasil/93</td>
<td>DS/RTG</td>
<td>8.61/19.36</td>
<td>12.91/49.44</td>
</tr>
<tr>
<td>Galdames IS</td>
<td>2010</td>
<td>Chile / 312 (284 Brasilian skulls)</td>
<td>DS</td>
<td>1.6/13.14</td>
<td>3.84/22.43</td>
</tr>
<tr>
<td>Devi Jansirani</td>
<td>2012</td>
<td>India/204</td>
<td>DS</td>
<td>0.98/10.78</td>
<td>2.45/3.92</td>
</tr>
<tr>
<td>Yadav A</td>
<td>2014</td>
<td>India/ 500</td>
<td>DS</td>
<td>4/6.2</td>
<td>-/-</td>
</tr>
<tr>
<td>Kavitha Kamath B</td>
<td>2014</td>
<td>India/100</td>
<td>DS</td>
<td>1/16</td>
<td>1/-</td>
</tr>
<tr>
<td>Sol-Ji Ryu</td>
<td>2016</td>
<td>Korea/ 142</td>
<td>DS</td>
<td>2.8/33.1</td>
<td>5.6/11.2</td>
</tr>
<tr>
<td>Rasimi Ghai</td>
<td>2016</td>
<td>India/50</td>
<td>DS</td>
<td>2/-</td>
<td>-/-</td>
</tr>
<tr>
<td>Present study</td>
<td>2017</td>
<td>Bosnia and Herzegovina / 100</td>
<td>DS</td>
<td>4/16</td>
<td>15/20</td>
</tr>
</tbody>
</table>

We found completely ossified pterygoalar ligament in 15% of observed skulls, with a higher frequency comparing to frequency noted by Rosa et al. (12.91%), two times higher frequency comparing to results of Peker et al. (7.5%), seven times higher frequency than those reported by Antonopoulou et al. and nearly fifteen times greater frequency comparing to those in a study of RS Tubbs et al (1.3%). We found mean maximum diameter of pterygoalar foramen measuring 3.16 mm (SD 1.28), which is compatible with findings of Jansirani [33]. Approximately two times bigger diameter was noted in a study of Galdames et al. 5.2 mm, two and a half bigger diameter in study performed by Skrzat et al. 8.4±1.79 mm and three times bigger diameter noted by RS Tubbs 9.42 mm when compared to our study [6,30,34]. Rosa et al. in their radiological anatomical study noted almost exclusively medial position of pterygospinous foramen with regard to oval foramen, while we found lateral positioned pterygospinous foramen in 50% of cases, medial positioned in 25% and another 25% frequency of overlapping position of pterygospinous foramen with regard to oval foramen [32]. Similar results have been found regarding to the position of pterygoalar foramen in correlation with oval foramen which corresponds to earlier studies.

CONCLUSION

Knowledge of anatomical variations of lateral pterygoid plate of sphenoid bone and ossification of pterygospinous and pterygoalar ligaments allows more accurate interpretation of radiological images and more efficient execution of procedures that require access to foramen ovale, infratemporal fossa and parapharyngeal region. There are racial, crosscultural and gender related differences in the incidence and morphological characteristics of ossified pterygospinous and pterygoalar ligaments. In this study was observed a higher frequency of all forms of ossification in male humans compared with left-sided predominance. Due to the greater thickness of the pterygoalar bony bar increases possibility for blood vessel and nerv entrapment and more often super or latero-position with oval foramen makes it more difficult or impossible to reach oval foramen, what is from great importance while performing percutaneous mandibular or trigeminal nerve block. However, one should not neglect the frequency nor the clinical significance of ossified pterygospinous ligaments.

DECLARATION OF INTEREST

The authors declare no conflicts of interest.

REFERENCES


