Detailed anatomy of the retaining ligaments of the mandible for facial rejuvenation

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ABSTRACT

Purpose: To present anatomical characteristics of three true ligaments of the mandible and better understanding of jowl formation.

Materials and methods: Facial dissections were performed in 10 fresh cadavers (20 hemifaces) using 2.5 magnifying surgical loupes. Mental ligament, mandibular ligament, and mandibular osteocutaneous ligament were identified as thick fibrous tissue originating from the mandible.

Results: The location of the mental ligament was 9.1 ± 2.8 mm lateral to the midline and 8.4 ± 3.8 mm superior to the inferior border of the mandible. The medial mandibular ligament was located 28.9 ± 4.9 mm lateral to the midline and 8.4 ± 2.7 mm superior to the inferior border of the mandible. The mandibular osteocutaneous ligament was located 51.1 ± 4.5 mm lateral to the midline and 9.1 ± 3.1 mm superior to the inferior border of the mandible.

Conclusions: We investigated location and tension of two unfamiliar ligaments in the mandible, the mental and medial mandibular ligaments medial to the mandibular osteocutaneous ligament, and confirmed them as true ligaments by histology. Our findings suggest that the cause of the jowl formation is mainly descent of the cheek fat compartments, but not laxity of mandibular osteocutaneous ligament.

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1. Introduction

A thorough investigation of the layers and structures of facial anatomy is crucial when performing facial surgery. The retaining ligaments of the face represent additional information of this anatomy and are essential in understanding principles of facial aging and rejuvenation. Since Mitz and Peyronie’s description of the superficial musculoaponeurotic system (SMAS) in 1976 (Mitz and Peyronie, 1976), further studies have tried to characterize the understanding of retaining ligaments and their parts in SMAS-based facelift procedures. To achieve optimal advancement and redraping of ptotic facial tissues, the retaining ligaments must be transected and the SMAS flap reattached to underlying fixed structures (periosteum or deep fascia) to achieve lasting support for the mobilized tissue (Mendelson, 2002). These retaining ligaments have mostly consistent anatomic locations and are situated in predictable regions. Significant study assessing the retaining ligaments of the face has developed our knowledge in facial anatomy. However, formal characterization of the strength and biomechanical properties of these ligaments has yet to be described except for the study of Brandt et al. (2012).

The mandibular ligament is an osteocutaneous ligament that arises from the anterior third of the mandible and inserts directly into the dermis (Stuzin et al., 1992; Furnas, 1989; Ozdemir et al., 2002). Its fibres penetrate the inferior portion of the depressor anguli oris muscle (Langevin et al., 2008). Furnas (1989) described 2 tiers of linear series of parallel fibres 2–3 mm from each other,
located 1 cm from the inferior border of the mandible. Ozdemir et al. (2002) confirmed the presence of 2 distinct fibrous attachments and confirmed histologically the connection between the periosteum and overlying skin. Langevin et al. (2008) reported on the dimensions of the mandibular ligaments measuring 2 cm horizontally × 1.2 cm vertically and located 4.5 cm anterior to the angle of the mandible. Reece et al. (2008) identified another osteocutaneous ligamentous structure that travels as a posterior extension of the mandibular ligament originating 1 cm superior to the border of the mandible. They named this structure the mandibular septum. Huettner et al. (2015) did not find a well-defined mandibular septum running as a direct posterior extension as described by Reece et al. (2008). Instead, they identified platysma mandibular ligament which acts as a hammock preventing further descent of jowl fat into the neck. However, there were no investigations of the medial part to the mandibular osteocutaneous ligament. In this study, we evaluate the retaining ligaments around the mandible and clarify the ligament located medial side to the mandibular ligament. Furthermore, biomechanics of these ligaments were also investigated.

2. Materials & methods

Facial dissections were performed in 10 fresh cadavers (20 hemifaces) using 2.5 magnifying surgical loupes (male: 12, female: 8, mean age: 83.3 years). Subperiosteal dissections from lower gingivobuccal approach were performed to identify true osteocutaneous ligament around the mandible. Mental ligament, medial mandibular ligament, and mandibular osteocutaneous ligament were identified as thick fibrous tissue originating from the mandible. Immediately prior to biomechanical measurement, the ligamentous structures were sharply transected at the subperiosteal layer. The length (distance from proximal to distal end in horizontal plane), the distance from midline, and the distance from the inferior border of the mandible were measured using a digital caliper (CD-15cp, Mitutoyo, Japan). The tension of these fibrous structures was calculated using the force gauge (BFG 200N, Mecmesin, Slinfold, UK). To allow fixation of these ligamentous structure to the force gauge, a braided, non-absorbable suture (3.0 Nylon, Ethicon Inc, Sommerville, NJ) was used. Masson’s trichrome stain was used to confirm the histologic status of the ligamentous structures we found.

Under the Korean laws, research involving deceased persons generally is not human subject research and does not require review by the Catholic Medical Center Office of Human Research Protection Program (CMC OHRP) at School of Medicine, the Catholic University of Korea that deals with IRB certification.

Statistical analysis of the measurements was performed using student t-test (SPSS, Ver. 20.0, IBM, USA). The mean and standard deviation (SD) for the structures were calculated. A P value of less than 0.05 was considered significant.

<table>
<thead>
<tr>
<th>Location of the ligament</th>
<th>From lateral to the midline</th>
<th>From superior to the inferior border of the mandible</th>
<th>Length of the ligament</th>
<th>Tension of ligament</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male (mm)</td>
<td>Female (mm)</td>
<td>Total (mm)</td>
<td>Male (N)</td>
</tr>
<tr>
<td>From lateral to the midline</td>
<td>9.1 ± 3.0</td>
<td>9.2 ± 2.6</td>
<td>9.1 ± 2.8</td>
<td>.927</td>
</tr>
<tr>
<td></td>
<td>Male (mm)</td>
<td>Female (mm)</td>
<td>Total (mm)</td>
<td>Male (N)</td>
</tr>
<tr>
<td>From superior to the inferior border of the mandible</td>
<td>9.4 ± 4.3</td>
<td>6.9 ± 2.6</td>
<td>8.4 ± 3.8</td>
<td>.161</td>
</tr>
<tr>
<td>Length of the ligament</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male (mm)</td>
<td>10.2 ± 2.5</td>
<td>10.6 ± 3.3</td>
<td>10.4 ± 2.8</td>
<td>.749</td>
</tr>
<tr>
<td>From superior to the inferior border of the mandible</td>
<td>15.8 ± 4.4</td>
<td>12.9 ± 3.1</td>
<td>14.7 ± 4.1</td>
<td>.113</td>
</tr>
<tr>
<td>Length of the ligament</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male (mm)</td>
<td>14.2 ± 4.7</td>
<td>13.2 ± 4.6</td>
<td>13.8 ± 4.5</td>
<td>.654</td>
</tr>
</tbody>
</table>

Table 1

Biomechanical characteristics of true ligaments in the mandible.

ML: mental ligament, MML: Medial mandibular ligament, MOL: Mandibular osteocutaneous ligament.

\* p < 0.05.
3. Results

Three ligamentous structures arising from periosteum of mandible were noted. All three ligaments were consistently found (Table 1 & Fig. 1). First, the mental ligament was located at the mental tubercle (Fig. 2). The location of the mental ligament was 9.1 ± 2.8 mm lateral to the midline and 8.4 ± 3.8 mm superior to the inferior border of the mandible. The length and tension of the mental ligament were 10.4 ± 2.8 mm and 19.7 ± 11.8 N, respectively. There were two ligamentous structures, the medial mandibular ligament and the mandibular osteocutaneous ligament, which were located lateral to the mental ligament along the inferior border of the mandible.

Medial mandibular ligament was located 28.5 ± 4.9 mm lateral to the midline and 8.4 ± 2.7 mm superior to the inferior border of the mandible (Fig. 3). The length and tension of the medial mandibular ligament were 14.7 ± 4.1 mm and 20.6 ± 16.2 N, respectively. Mandibular osteocutaneous ligament was located 51.1 ± 4.5 mm lateral to the midline and 9.1 ± 3.1 mm superior to the inferior border of the mandible (Fig. 4). The length and tension of the mandibular osteocutaneous ligament were 13.8 ± 4.5 mm and 20.6 ± 13.1 N, respectively.

The location, length, and tension of all ligaments were not significantly different between each hemiface. In addition, differences in these values between male and female cadavers were statistically insignificant (P > 0.05). However, two values, the distance from the inferior border of the mandible in the medial mandibular ligament (P = 0.012) and the tension in the mandibular osteocutaneous ligament (P = 0.029), showed statistically significant differences between the sexes.

According to our study, mental ligament originated at the bony part at which the mentalis muscle and the depressor labii inferioris muscle interdigitate and their fibres penetrate the interdigitation. Medial mandibular ligament originated at the bony part at which the depressor labii inferioris muscle and the depressor anguli oris muscle interdigitate and their fibres penetrate the interdigitation. Mandibular osteocutaneous ligament originated at the bony part at which the inferolateral part of the depressor anguli oris muscle inserts (Fig. 5).

4. Discussion

Facial aging results from a combination of soft tissue descent and volumetric deflation (Furnas, 1989; Kikkawa et al., 1996).
loss of tissue elasticity combined with repetitive motion from muscle contraction and gravity is believed to cause tissue descent (Kikkawa et al., 1996). The precise role of the facial retaining ligaments in aging process is not well defined. Some authors believe that laxity of the retaining ligaments results in laxity and descent of the soft tissue they support (Furnas, 1989; Ozdemir et al., 2002; Reece et al., 2008; Stuzin et al., 1995). Another school of thought suggests that the ligaments remain relatively strong while the unsupported tissue in between (in the spaces and compartments) descends with time (Warren et al., 2011; Mendelson and Jacobson, 2008; Mendelson et al., 2008).

Either way, as the jowl forms, its anterior extension is limited by the mandibular ligament. The groove that forms just anterior to the jowl corresponds to the mandibular ligament.

In our opinion, jowl formation was not attributed only to the laxity of the mandibular osteocutaneous ligament. Unlike the jowl, which was the result of the aging process of the lower face, soft tissues below the lower lip were not sagged to be lifted surgically.

Furthermore, there were no considerable differences in the tensions of the ligaments among the three mandibular true ligaments (Table 1). According to these findings, the laxity of the mandibular osteocutaneous ligament was not the reason for the jowl formation. Reece et al. (2008) stated that the superior and inferior jowl fat compartments descend, secondary to attenuation of the mandibular septum. Huettner et al. (2015) claimed that jowl formation might best be described as follows: Laxity of the masseteric cutaneous ligaments leads to descent of jowl fat. Further, descent of jowl fat is checked by the anteriorly located mandibular cutaneous ligament that fixes the skin anterior to the mandibular ligament and serves as the structure defining the anterior-most border of the marionette lines. We agree with the novel identifications of Reece et al. (2008) and Huettner et al. (2015) in the point of jowl formation. However, our study did not identify the fibrous bony attachments arising from the mandible between the mandibular osteocutaneous ligament and the anterior border of the masseter muscle.

The mandibular ligament can be readily palpated as a tethering structure at the anterior-most location of the jowl/marionette lines. Release of the mandibular osteocutaneous ligament during facelift surgery is controversial. Some surgeons release the mandibular osteocutaneous ligament routinely during facelift surgery while others do not (Alghoul et al., 2013; Feldman, 2006). Huettner et al. (2015) insisted that release of the mandibular osteocutaneous ligament was beneficial when there was contour depression. We agree with this concept of surgical technique because the mandibular osteocutaneous ligament has its role as a check ligament. Nevertheless, if the surgeon decided to dissect the mandibular osteocutaneous ligament according to its necessity, it is also practicable only if there was no injury of the marginal mandibular nerve (Fig. 6). The medial mandibular ligament has compensatory function as a check ligament; therefore, the midline soft tissues could not shift to the lateral side.
Previous reports have sought to quantify the physical dimensions of the mandibular osteocutaneous ligaments. While these reports have elucidated the consistent location of these ligaments, wide variation exists in the measured dimensions (Furnas, 1989; Ozdemir et al., 2002). Furnas (1989) found the mandibular ligament to be 4–5 mm in length, whereas Ozdemir et al. (2002) described a length of 24–32 mm in men and 22–31 mm in women. Huettner et al. (2015) identified a length of 11.7–14.5 mm. Brandt et al. (2012) reported a length of 6.5–13.5 mm. Lengths in our investigation ranged from 9.3 to 18.3 mm.

The variation seen among studies of the mandibular osteocutaneous ligament persists in the tension of the mandibular osteocutaneous ligament. Brandt et al. (2012) reported that the force to ultimate failure for mandibular ligament was 15.7 ± 2.3 N. Our investigation showed that the tension of the mandibular osteocutaneous ligament was 20.6 ± 13.1 N.

It is laborious to account for the variation in the measured ligament’s characteristics. Perhaps, variations of dissection plane or measurement techniques have resulted in a gap among the investigations. We dissected through the subperiosteal layer to confirm the true osteocutaneous ligament. It might be the reason why the tension of the mandibular osteocutaneous ligament was greater than that reported by Brandt et al. (2012).

We identified two true osteocutaneous ligaments, the mental ligament and the medial mandibular ligament, which were not used widely in the literature (Fig. 7). Because of these ligaments, soft tissues below the lower lip were not easily descended or sagged. If the mandibular osteocutaneous ligament was released for its necessity, these ligaments could act like a check ligament.

Finally, it should be noted that our results showing the detailed anatomical location and histology of three mandibular ligaments may provide useful information to facial plastic surgeons who perform orthognathic surgery, trauma surgery and preprosthetic surgery. Although a negative outcome is rarely seen, despite the fact that hardly ever are any of these ligaments refixed, surgeons are used to dissecting the named ligaments on a regular basis and reapproximating the mentalis muscle to avoid drooping chin (Rodriguez et al., 2012), because the mentalis muscle can lift skin and soft tissue (Affi and Djohan, 2012).

5. Conclusion

Mental and medial mandibular ligaments have not been widely introduced. We investigated a clinical significance through identifying the location and tension of those two unfamiliar true ligaments and the mandibular osteocutaneous ligament. Limitations of our study are acknowledged. The small number of fresh cadavers and difference of dissection plane compared with other studies might weaken the conclusion of our study. However, we clarified the true ligaments confirmed by histology medial to the mandibular osteocutaneous ligament and measured the tension of those ligaments. Our findings suggest that the cause of the jowl formation is mainly descent of the cheek fat compartments, but not laxity of mandibular osteocutaneous ligament. With further investigation in sub-SMAS plane or correlation with clinical experiences, rejuvenation techniques of the lower face can be enriched.

Disclosure

None of the authors has any financial interest in the products, devices, or drugs mentioned in this article.

References


