ISSN- 0102-9010

BILAMINAR ZONE: ANATOMICAL ASPECTS, IRRIGATION, AND INNERVATION

Selma Siéssere[1,2], Mathias Vitti[1], Luiz Gustavo de Sousa[1], Marisa Semprini[1] and Simone Cecílio Hallak Regalo[1]

[1]Department of Morphology, Stomatology and Physiology, Ribeirão Preto School of Dentistry / São Paulo University, Ribeirão Preto, SP and [2] Uberaba School of Dentistry / Uberaba University, Uberaba, MG, Brazil.

ABSTRACT

The temporomandibular joint, a synovial joint of great importance in dentistry, consists of articular surfaces, ligaments, and the articular disk. The posterior region of the disk or bilaminar zone consists of upper layer that is attached to the posterior wall of the mandibular fossa (anterior rim of the petrotympanic fissure) and a lower layer that is attached to the posterior region of the mandibular head and forms the posterior limit of the disk. Lesions in this regions caused by distention, trauma or pressure can lead to luxation of the disk and temporomandibular disorders that may or may not be accompanied by degenerative alterations. In this work, we examined the anatomy of the bilaminar zone, as well as its irrigation and innervation. Five human heads fixed in 10% formalin underwent medial sagittal sectioning followed by dissecting. The bilaminar zone was irrigated by the superficial temporal artery and the anterior tympanic and deep auricular arteries. Innervation of this region was by the sensorial terminations of the auriculotemporal nerve. These findings indicated that the bilaminar zone was located in a highly innervated and vascularized area in the posterior region of the disk.

Key words: Articular disk, auriculotemporal nerve, retrodiskal pad, temporomandibular joint, vascularization

INTRODUCTION

The temporomandibular joint (TMJ) is a synovial joint consisting of the mandibular head, mandibular fossa, articular tuberosity, articular disk, and a capsule with reinforcement and accessory ligaments [12]. The articular disk, which is located between the articular surfaces of the mandibular head and the temporal bone [16,19], is connected to the articular capsule by the lateral and posterior insertions, that divide the articular space into upper and lower compartments [14]. These insertions also adapt to the rotational changes of the mandibular head by gliding across the different parts of the temporal bone [10]. The disk varies in thickness throughout its extension and has four clearly defined transverse ellipsoidal regions known as the anterior, intermediate and posterior bands and bilaminar zone. Electronic microscopy of the articular disk has shown that the various regions of the disk contain bundles of collagen fibers arranged in many directions [11].

Correspondence to: Dr. Mathias Vitti
Departamento de Morfologia, Estomatologia e Fisiologia, Faculdade de Odontologia de Ribeirão Preto, Universidade de São Paulo – USP, Avenida do Café, s/n, Bairro: Monte Alegre, CEP: 14040-904 , Ribeirão Preto, SP, Brasil. Tel: (55) (16) 602-4015, Fax: (55) (16) 633-0999. E-mail: mvitti@forp.usp.br

Macroscopically, the bilaminar zone consists of an upper layer that is attached to the back of the posterior wall of the mandibular fossa and the squamo-tympanic suture, and a lower layer that is attached to the back of the mandibular head [14]. An intermediate layer is observed between the upper and lower strata [4,17,19]. The upper and lower layers form the posterior limit of the disk. Lesions in this region caused by distention, trauma or pressure can lead to luxations of the disk and temporomandibular disorders that may or may not be accompanied by degenerative alterations [15].

Few studies have examined the structure and function of the TMJ and conclusions regarding articular function and dysfunctions have been based on morphological analyses [1]. There is therefore a need for detailed study of the morphology of the TMJ, including the bilaminar zone to facilitate the precise diagnosis of the temporomandibular disorders by the dentist. In this study, we examined the anatomy of the bilaminar zone and its irrigation and innervation.

MATERIAL AND METHODS

Five human heads (all males, average age 40 years old) were fixed in 10% formalin and sectioned in the medial sagittal plane.

Dissection was initiated on the external or lateral surface of the TMJ with the skin, tela subcutanea, vessels, and nerves being removed, as well as the parotid gland, adipose tissue, and pterygomandibular venous plexus. The temporal and masseter muscles were also partially removed. In the medial region, the connective and adipose tissues, vessels, and nerves were removed to reveal the TMJ region and, consequently, the bilaminar zone.

RESULTS

The upper and lower layers of the bilaminar zone corresponded to the upper and lower short fibers. The upper short fibers extended from the articular disk to the temporal bone and, since they were shorter than the lower fibers, they kept the upper-posterior edge of the articular disk closer to the temporal bone. The lower short fibers extended from the articular disk to the mandible. This anatomical arrangement also allowed visualization of the long fibers, which extended from the temporal bone to the mandible. The area of bone intersection of the short and long fibers was the same. The region of the short fibers close to the disk formed the anterior wall of the retrodiskal pad, while the distal portion connected to the long fibers and inserted into a common site on the bone. This close association of the short and long fibers at the capsule's point intersection resulted in the formation of a single layer (Figs. 1-3).

In the posterior region of the disk, the short and long fibers were distant and bordered the retrodiskal pad, an area that was thoroughly vascularized and innervated (Fig. 1). The bilaminar zone was irrigated by superficial temporal arteries and by branches of the maxillary artery represented by anterior tympanic and auricular deep arteries. The anterior tympanic and deep auricular arteries showed some variation in their origin, although both derived from a common stem. The bilaminar zone was innervated by sensorial terminations of the auriculotemporal nerve (Figs. 4-8).

DISCUSSION

The description of the TMJ, by Ress [14] clearly revealed the presence of the bilaminar zone, which served to connect the articular disk posteriorly to other articular structures.

Histologically, the anterior, intermediate, and posterior bands of the articular disk consists of dense connective tissue [7]. According to Minarelli [11], the constituent bundles of collagen fibers are stratified and oriented anteroposteriorly, laterolaterally and obliquely in the middle portion of the disk. A ring of laterolateral bundles constitutes the main feature of the thick posterior portion. In the anterior portion of the disk, the fibers are oriented anteroposteriorly and obliquely. On the upper and lower surfaces of the disk a thin layer of perpendicular arranged collagen fibers covers the underlying, thick, laterolaterally oriented collagen fibers.

The upper layer of the bilaminar zone is thicker than the lower layer and consists of loose connective tissue that contains elastic fibers [1,7] and adipose tissue [7]. The lower layer of the bilaminar zone is composed of loose connective tissue [7] and contains relatively few elastic fibers [1,3,13,14]. The retrodiskal pad corresponds to the intermediate layer [4,17,19] and, according to Madeira [9] and Scapino [17], this region is vascularized and innervated and also composed of loose connective tissue with elastic fibers. Ours findings confirmed that bilaminar zone is vascularized, innervated and contains adipose tissue, although a high amount of collagen fibers was also observed. The retrodiskal pad is also a source of synovial liquid, since it is covered by the synovial membrane [15].

The retrodiskal pad and the upper and the lower layers of the bilaminar zone limit the excursion of the mandibular head and the articular disk during the

Figure 1. Sagittal section of the TMJ. Side view. **1** – Bilaminar zone ({). **2** – Retrodiscal pad. **3** – Superior short fibers. **4** – Inferior short fibers. **5** – Articular disk. **6** – Mandibular fossa. **7** – Mandibular head. **8** – External acoustic pore. **9** – Vessel

Figure 2. Sagittal section of the TMJ. Medial view. **1** – Bilaminar zone ({). **2** – Retrodiscal pad. **3** – Superior short fibers. **4** – Inferior short fibers. **5** – Articular disk. **6** – Long fibers. **7** – Mandibular fossa. **8** – Mandibular head

Figure 3. Frontal section of the TMJ. Internal View. **1** – Superior short fiber. **2** – Articular disk. **3** – Inferior short fibers. **4** – Mandibular head. **5** – Mastoid process.

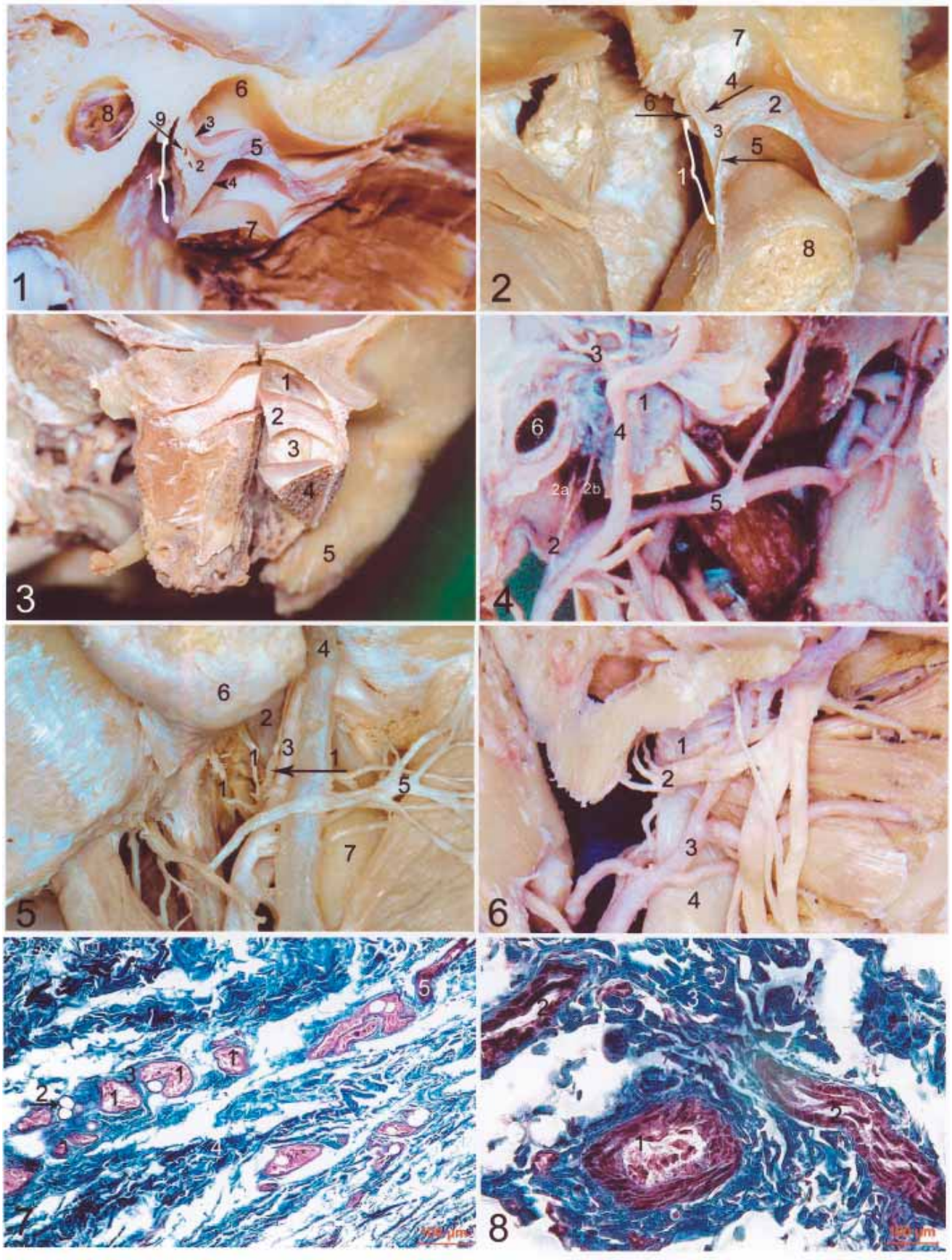
Figure 4. Side view of the TMJ. **1** – TMJ. **2** – Common stem. **2A** – Anterior tympanic artery. **2B** – Deep auricular artery. **3** – Anterior auricular ramification of the superficial temporal artery. **4** – Superficial temporal artery. **5** – Maxillary artery. **6** – External acoustic pore.

Figure 5. Side view of a human head. **1** – Auriculotemporal nerve. **2** – Articular capsule. **3** – Superficial temporal artery. **4** – Superficial temporal vein. **5** – Facial nerve. **6** – Outer ear. **7** – Mandibular ramus.

Figure 6. Medial view of a human head showing a section of the temporal bone. **1** – TMJ. **2** – Auriculotemporal nerve. **3** – Maxillary artery. **4** – Mandibular ramus.

Figure 7. Light photomicrograph of a bilaminar zone in a human TMJ (Masson's trichrome). **1** – Nerve. **2** – Adipose tissue (**arrow**). **3** – Loose connective tissue. **4** – Collagen fibers. **5** – Venule.

Figure 8. Light photomicrograph of the bilaminar zone in a human TMJ (Masson's trichrome). **1** – Arteriole. **2** – Venule. **3** – Collagen fibers.


1
2
3
4
5
6
7
8

mandibular propulsion and become active components during antagonistic movement [5,15]. Although they oppose the action of the lateral pterygoid muscle, the bilaminar zone layers do not compete, in terms of traction, with the tones of this muscle, which is dominant and maintains the disk in the appropriate anterior position [15].

The central region of the articular disk is not vascularized and metabolism in this area is regulated lymphatically and by synovial liquid [3]. In contrast, the retrodiskal region is highly vascularized [3,7]. Using light electron microscopy, Benigno *et al.* [2] recently demonstrated the vascularization of the retrodiskal region and, as shown here, arterial blood is supplied to this region by temporal superficial arteries, as well as the anterior tympanic and deep auricular arteries. Our results confirmed the report by Stingl [18] concerning the irrigation of the bilaminar zone.

Our results regarding the innervation of the bilaminar zone agreed with the findings of Dixon [4] and Thilander [20] who reported this zone to be innervated by the sensorial terminations of the auriculotemporal nerve.

Based on histological studies of the bilaminar zone, Kino *et al.* [8] concluded that the upper and lower layers of the zone, which were initially named and described by Ress [14], did not exist. However, our anatomical analysis of this zone showed that the upper and lower layers were quite evident. Recent studies using magnetic resonance have also confirmed the visualization of the upper and lower layers of the bilaminar zone [6].

In conclusion, our results have identified the main anatomical structures that form the bilaminar layer. These findings extended our knowledge of this region and should facilitate the diagnosis of the temporo-mandibular disorders.

ACKNOWLEDGMENTS

The authors thank Nilce de Oliveira Wolga for preparing the histological slides and Luisa Caliri Juzzo for translating this paper into English.

REFERENCES

1. Ash MM, Ramfjord SP, Scmidseder J (1998) Articulações temporomandibulares: estrutura, função e disfunção. In: *Oclusão*. Editora Santos: São Paulo, pp. 17-30.
2. Benigno MI, Azeredo RA, Lemos JL, Konig Junior B, Liberti EA (2001) The structure of the bilaminar zone in the human temporomandibular joint: a light and scanning electron microscopy study in young and elderly subjects. *J. Oral Rehabil.* **28**, 113-119.
3. Boering G (1979) Anatomical and physiological considerations regarding the temporomandibular joint. *Int. Dent. J.* **29**, 245-251.
4. Dixon AD (1962) Structure and functional significance of the intra-articular disk of the human temporomandibular joint. *Oral Surg. Oral Med. Oral Pathol.* **15**, 48-61.
5. Figún ME, Garino RR (1994) Artrologia. In: *Anatomia Odontológica Funcional e Aplicada*. Editora Guanabara Koogan: Rio de Janeiro, pp. 49-60.
6. Haiter-Neto F, Hollender L, Barclay P, Maravilla KR (2002) Disk position and the bilaminar zone of the temporomandibular joint in asymptomatic young individuals by magnetic resonance imaging. *Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod.* **94**, 372-378.
7. Katchburian E, Arana V (1999) Articulação temporomandibular. In: *Histologia e Embriologia Oral*. Editora Guanabara Koogan: Rio de Janeiro, pp.355-373.
8. Kino K, Ohmura Y, Amagasa T (1993) Reconsideration of the bilaminar zone in the retrodiskal area of the temporomandibular joint. *Oral Surg. Oral Med. Oral Pathol.* **75**, 410-421.
9. Madeira MC (1998) Articulação temporomandibular. In: *Anatomia da Face.* Editora Sarvier: São Paulo, pp. 81-96.
10. McKay GS, Yemm R, Cadden SW (1992) The structure and function of the temporomandibular joint. *Br. Dent. J.* **173**, 127-132.
11. Minarelli AM, Del Santo Jr M, Liberti EA (1997) The structure of the human temporomandibular joint disc: a scanning electron microscopy study. *J Orofac. Pain* **11**, 95-100.
12. Mongini F (1998) Articulação temporomandibular. In: *ATM e Músculos Craniocervicofaciais: Fisiopatologia e Tratamento.* Santos Livraria Editora: São Paulo, pp. 29-44.
13. Piette E (1993) Anatomy of the human temporomandibular joint. An update comprehensive review. *Acta Stomatol. Belg.* **90**, 103-127.
14. Ress LA (1954) The structure and function of the mandibular joint. *Br. Dent. J.* **96**, 125-133.
15. Rizzolo RJC, Madeira MC (2004) Sistema articular. In: *Anatomia Facial com Fundamentos de Anatomia Sistêmica Geral*. Editora Sarvier: São Paulo, pp. 113-142.
16. Scapino RP (1983) Histopathology associated with malposition of the human temporomandibular joint disk. *Oral Surg. Oral Med. Oral Pathol.* **55**, 382-397.
17. Scapino RP (1991) The posterior attachment: its structure, function, and appearance in TMJ imaging studies. Part 1. *J. Craniomandib.Disord.* **5**, 83-95.
18. Stingl J (1965) Blood supply of the temporomandibular joint in man. *Folia Morphol.* **13**, 20-26.
19. Straus F, Christen A, Weber W (1960) The architecture of the disk of the human temporomandibular joint. *Helv. Odontol. Acta.* **4**, 1-4.
20. Thilander B (1964) Innervation of the temporomandibular disk in man. *Acta Odontol. Scand.* **22**, 151-156.

Received: April 13, 2004
Accepted: November 19, 2004