The Articular-Synovial Lining Tissue System in Temporomandibular Joints of Young Adults

Carol A. Bibb, PhD, DDS
Adjunct Associate Professor
Section of Orofacial Pain and Occlusion

Andrew G. Pullinger, DDS, MSc
Associate Professor
Section of Orofacial Pain and Occlusion and Dental Research Institute

School of Dentistry
Center for Health Sciences
University of California
Los Angeles, California 90024

Fernando Baldioceda, DDS, MS
San Jose, Costa Rica

Correspondence to Dr Bibb

The histologic character of the articular surfaces and synovial tissues in the temporomandibular joints of 20 young adults was described. Each joint compartment had a continuous connective-tissue lining that was fibrous on the articular surfaces, went through a transition, and was continuous with the lining tissue in the recesses. Areolar synovial tissue was found only in the upper posterior recess of the temporomandibular joint, fibrous synovial tissue was predominately found in the upper anterior and lower posterior recesses, and an intermediate type of synovial tissue was found in the lower anterior recess. There was no distinct boundary between articular and synovial tissue. The structure and continuity of these lining tissues suggest that they constitute a continuous tissue system, here termed the "articular-synovial lining tissue system," that has a histologic character which depends on location and functional demands. It is hypothesized that all of the lining tissues should be considered synovial, based on a functional definition of nonadherence.

J OROFACIAL PAIN 1993;7:241–246.

The temporomandibular joint (TMJ) is a synovial joint that is characterized by the unusual feature of articular surfaces composed of fibrous connective tissue (rather than hyaline cartilage), and it has a proliferative cartilage zone beneath. The TMJ articular disc completely divides the joint into separate upper and lower compartments, with sliding and hinging functions occurring respectively in these divisions. These specialized features of structure and function suggest that caution be exercised when generalizing from the specific pathophysiology of other synovial joints.

The articular fibrous connective tissue layer of the TMJ has been assumed to be passive,[1] while the remodeling and adaptive response to loading have been attributed to the proliferative cartilage layer.[2–5] However, recent studies have emphasized the importance of the articular fibrous connective tissue in maintaining an intact articular surface[6] and moderating underlying osseous defects.[7] The fibrous connective-tissue layer may not be as passive as previously thought, since, in these studies, this layer contributed to and correlated with variations in overall soft tissue thickness as much as did the cartilage layer.[6] Furthermore, the fibrous connective tissue layer was always present, even in sites where the articular soft tissue completely lacked a cartilage layer, and this configuration was not associated with signs of arthrosis in the young adult sample studied.[6,7]

The structure and interrelationships of the fibrous articular lining tissues and synovial tissues in the TMJs of young adults have

important clinical implications. Presumably, these tissues play a role in maintaining intact and nonadherent articular surfaces between functionally juxtaposed components. In addition, these tissues must have the capacity to accommodate to changes in loading due to disc displacement disorders that alter the relationship between joint components.

The synovial tissues of the TMJ have been arthroscopically and histologically described by Murakami and Hoshino.[8] These authors applied Key's classical divisions of synovial tissue into areolar, adipose, and fibrous types[9] to the TMJ. However, the relative distribution of synovial tissue within the joint and the relationship between the articular surface tissues and synovial tissues have not been studied. The purpose of the present investigation was to describe the histologic character of the articular surfaces, the distribution of synovial tissue, and the relationship between articular and synovial tissues in the TMJs of young adults.

Materials and Methods

Sample

The sample consisted of 20 intact TMJ specimens (mean age 26.5 years; 13 male and 7 female) collected during autopsy and prepared by Solberg et al.[10] One sagittal section from the central third of each joint was selected for detailed study because it is the part of the joint that can be most reliably sectioned perpendicular to the articular surface. In addition, lateral and medial sections were examined when available.

Procedure

The surface tissues lining each joint compartment were examined under low-power light microscopy. The articular surfaces of the condyle, temporal component, and disc were identified histologically by the presence of dense, fibrous connective tissue. The histologic appearance within each joint was compared in juxtaposed locations of presumed loading, those being the articular eminence of the temporal component, the anterosuperior aspect of the condyle, and the functional zone of the disc. The synovial tissue in the four recesses of each joint was classified according to a modification of Key's original categories:

1. *Areolar:* characterized by increased surface area over loose connective tissue with a vascular bed.
2. *Fibrous:* dense fibrous connective tissue indistinguishable from the articular fibrous connective tissue.
3. *Intermediate:* having histologic features midway between the areolar and fibrous types.

Results

Every joint compartment had a surface lining of connective tissue that was continuous around the entire joint cavity. This connective tissue was dense, fibrous connective tissue on the articular surfaces of the condyle, temporal component, and disc, with synovial tissue (as classified above) localized to the recesses (Fig 1). No distinct boundary occurred between the articular and synovial tissues; instead a region of gradual transition, defying distinct classification into either synovial or articular connective tissue, was seen (Fig 2).

Tables 1 through 3 show the distribution of each category of synovial tissue by joint recess in central, medial, and lateral sections respectively. Areolar synovial tissue (Fig 3) was only observed in the upper posterior recess, while fibrous synovial tissue (Fig 4) was most common in the upper anterior (17 of 19 joints) and lower posterior (18 of 20 joints) recesses. In the latter two recesses, there was no histologic difference between articular fibrous connective tissue and the fibrous synovial tissue. In particular, the upper anterior recess had a characteristic histologic appearance of a cleft

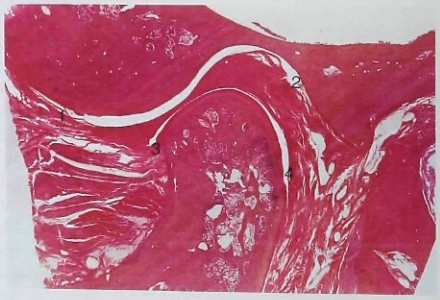

Fig 1 Sagittal histologic section from the central third of a joint of a 16-year-old female subject. Dense fibrous connective tissue covers the functional articular surfaces of the condyle and temporal component, as well as the upper and lower surfaces of the disc. Synovial tissue is localized to the recesses termed the upper anterior (1), upper posterior (2), lower anterior (3), and lower posterior (4).

Table 1 Distribution of Synovial Tissue Categories in TMJ Central Sections (n = 20)

Recess	Areolar	Intermediate	Fibrous	Not judgable
Upper anterior	0	2	17	1
Upper posterior	9	9	1	1
Lower anterior	0	13	6	1
Lower posterior	0	2	18	0

Table 2 Distribution of Synovial Tissue Categories in TMJ Medial Sections (n = 17)

Recess	Areolar	Intermediate	Fibrous	Not judgable
Upper anterior	0	0	11	6
Upper posterior	8	8	1	0
Lower anterior	0	8	7	2
Lower posterior	0	1	16	0

Table 3 Distribution of Synovial Tissue Categories in TMJ Lateral Sections (n = 12)

Recess	Areolar	Intermediate	Fibrous	Not judgable
Upper anterior	0	2	10	0
Upper posterior	2	4	6	0
Lower anterior	0	6	6	0
Lower posterior	0	1	11	0

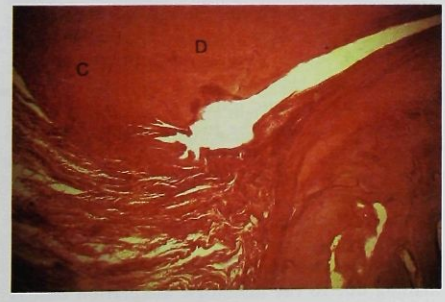

Fig 2 Lower anterior recess of the same joint at higher magnification. Note the continuity of the synovial tissue with articular fibrous connective tissue on the functional lower surface of the disc (D) and the anterior articular surface of the condyle (C). This recess has the intermediate type of synovial tissue.

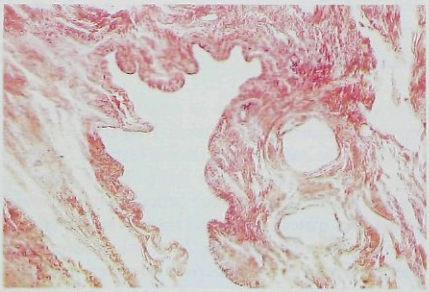

Fig 3 Areolar synovial tissue located in the upper posterior recess.

Fig 4 Fibrous synovial tissue located in the upper anterior recess. Note that this tissue is histologically indistinguishable from the fibrous articular tissue of the temporal component (T).

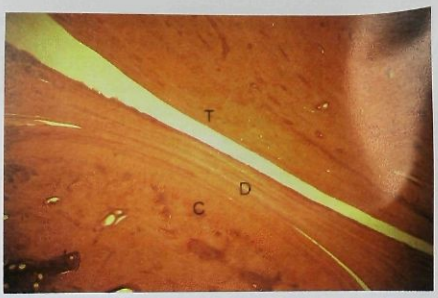

Fig 5 Articular surfaces that are histologically identical on functionally juxtaposed surfaces of the condyle (C), disc (D), and temporal component (T).

in the articular tissue, rather than a distinct recess, in all 17 of the 19 joints described as having fibrous synovial tissue (Fig 4). Synovial tissue intermediate between the areolar and fibrous types (Fig 2) was most common in the lower anterior recess, with fibrous synovial tissue also being common in this location.

The histologic character of the articular fibrous connective tissue in functionally juxtaposed regions of the articular eminence, disc, and condyle was identical in 19 of the 20 joints in this sample (Fig 5), including 3 joints with displaced discs. The joint that did not show a histologic similarity between functionally opposed surfaces also had a displaced disc.

Discussion

This study has described an articular-synovial lining tissue system in the human TMJ that is consistent with the various specialized features of structure and function in this joint. There were no distinct boundaries between articular and synovial tissues, but instead a gradual transition in histologic character was seen (Fig 2). Furthermore, there was no apparent distinction between articular fibrous connective tissue and fibrous synovial tissue, this being particularly true in the upper anterior recess (Fig 4). The term articular-synovial lining tissue system was proposed to emphasize the continuity of these lining tissues around the joint cavities. From a clinical standpoint, it is therefore not surprising that visual inspection during arthroscopic examination does not reveal obvious boundaries on the surface tissues. [8,11]

The reported distribution of synovial tissue is in general agreement with the findings of Murakami and Hoshino,[8] who described areolar synovial tissue in the upper posterior and lower anterior recesses, fibrous in the upper anterior recess, and adipose in the lower posterior recess. However, in the present study, the introduction of a category of synovial tissue with characteristics intermediate between those of areolar and fibrous tissues was necessary to accurately describe the observed range of morphologic variation. This is compatible with Key's work,[9] which indicated that mixed types of synovial tissue occur in addition to the three main categories.

This study supports the concept that the articular fibrous connective tissue, as the actual articular surface, is more important than previously described. It is believed[9] that a necessary requirement for physiologic movement of one surface over another is that the functionally juxtaposed surfaces should be of identical histologic structure. Only 1 joint in this sample showed dissimilar juxtaposed surfaces. Since it was one of the 4 joints with disc displacement, it is hypothesized that it may represent a recent displacement. With time, it may acquire the same fibrous nature in areas of loading due to the histologic adaptation that is presumed to have already occurred in the other 3 joints with displaced discs.

Using a functional definition of nonadherence,[9] it may be conceptually useful to consider all of the TMJ lining tissues synovial. By this definition, synovial surfaces are nonadherent in that they adhere to the matrix on which they rest but not to the

opposing surface, despite their identical histologic structure. This concept should direct our attention to the surface characteristics responsible for nonadherence and conversely to the mechanism by which opposed surfaces may adhere in some cases of joint locking. The fibrous, cleftlike characteristic of the upper anterior recess (Fig 4) would appear to be a natural site for adherence, since the opposed surfaces are most similar. Closing off of the recess might be expected if the environment responsible for nonadherence is changed. This could be the result of physical immobilization of the disc or a response to inflammation. This is consistent with the observation by Murakami[12] that fibrous adhesion is sometimes observed in the upper anterior recess in patients with persistent closed lock. At the same time it must be emphasized that most clicking joints do not progress to continuous locking, so arthroscopic intervention in clicking joints is not supported by this study.

Conclusion

From a developmental and evolutionary perspective, synovial lining tissues represent a primitive and basic connective tissue response to cavitation, which is seen in all vertebrates.[9] There are numerous examples in which loose connective tissue shows the capacity to form a nonadherent lining in response to the presence of an internal space. These examples include experimentally induced pseudoarthroses, regenerating tissues around artificial joints, adventitious bursae formed by athletic injuries, and experimental air pouches, which all produce lining tissues similar to those seen in synovial joints per se.[9] The TMJ articular-synovial lining tissue system described in this paper is another example of this basic connective tissue response. It is believed that this tissue system is an adaptive feature that maintains nonadherent, fibrous articular tissue in areas of loading despite morphologic changes in the underlying cartilage and bone and disc displacements.

References

1. Blackwood HJJ. Cellular remodeling in articular tissue. J Dent Res 1966;45:480–489.
2. Hansson TL, Nordstrom BB. Thickness of the soft tissue layers and articular disk in temporomandibular joints with deviations in form. Acta Odontol Scand 1977;35:281–288.
3. Hansson TL, Öberg T, Carlsson GE, Kopp S. Thickness of the soft tissue layers and the articular disk in the temporomandibular joint. Acta Odontol Scand 1977;35:77–83.
4. McNamara JA, Hinton RJ, Hoffman DL. Histologic analysis of temporomandibular joint adaptation to protrusive function in young adult Rhesus monkeys (Macaca mulatta). Am J Orthod 1982; 82:288–298.
5. Lubsen CC, Hansson TL, Nordstrom BB, Solberg WK. Histomorphometric analysis of cartilage and subchondral bone in mandibular condyles of young adults at autopsy. Arch Oral Biol 1985;30:129–136.
6. Pullinger AG, Baldioceda F, Bibb CA. Relationship of TMJ articular soft tissue to underlying bone in young adult condyles. J Dent Res 1990;69:1512–1518.
7. Baldioceda F, Bibb CA, Pullinger AG. Distribution and histological character of osseous concavities in mandibular condyles of young adults. J Craniomandib Disord Facial Oral Pain 1990;4:147–153.
8. Murakami K, Hoshino K. Histological studies on the inner surfaces of the articular cavities of human temporomandibular joints with special reference to arthroscopic observations. Ant Anz 1985;160:167–177.
9. Henderson B, Edwards JCW. The Synovial Lining in Health and Disease. London: Chapman and Hall, 1987: 3, 10–11, 21–23, 42.
10. Solberg WK, Hansson TL, Nordstrom B. The temporomandibular joint in young adults at autopsy: A morphologic classification and evaluation. J Oral Rehabil 1985; 12:303–321.
11. Bibb CA, Pullinger AG, Baldioceda F, Murakami K, Ross JB. Temporomandibular joint comparative imaging: Diagnostic efficacy of arthroscopy compared to tomography and arthrography. Oral Surg Oral Med Oral Pathol 1989;68:352–359.
12. Murakami K. In: Sanders B, Murakami K, Clark GT (eds). Diagnostic and Surgical Arthroscopy of the Temporomandibular Joint. Philadelphia: Saunders, 1989:20.

Resumen

Sistema Tisular de Revestimiento Articular-sinoval en las Articulaciones Temporomandibulares de Adultos Jovenes

Se describen las características histológicas de las superficies articulares y el tejido sinovial en las articulaciones temporomandibulares (ATM) de 20 adultos jóvenes. Cada compartimiento articular presentaba un revestimiento continuo de tejido conectivo que era fibroso en las superficies articulares, que había sufrido una transición, y que se continuaba con el tejido de revestimiento en las depresiones. Se encontró tejido sinovial areolar sólo en la depresión postero-superior de la ATM; el tejido sinovial fibroso era mas prevalemente en las depresiones antero-superior y postero-inferior. Se encontró también un tejido sinovial de tipo intermedio en la depresión antero-inferior. No se encontró un límite claro entre el tejido articular y sinovial. La estructura y continuidad de estos tejidos de revestimiento indican que estos constituyen un sistema tisular continuo, cuya denominación es "sistema tisular de revestimiento articular-sinovial", en el cual las características histológicas dependen de la localización y de las demandas funcionales. Se plantea la hipótesis de que todos los tejidos de revestimiento deberían ser considerados como sinoviales, basados en una definición funcional de falta de adherencia.

Zusammenfassung

Artikulär-synoviale Gewebe in Kiefergelenken junger Erwachsener

Diese Studie beschreibt die Histologie der Gelenkoberflächen und der synovialen Gewebe von 20 Kiefergelenken junger Erwachsener. Jedes Gelenkkompartiment wies eine durchgehende Bindegewebsschicht auf, die im Bereich der Gelenkoberflächen fibrös war und sich nach einer Uebergangszone im oberflächlichen Gewebe der Recessi fortsetzte. Synovialgewebe vom areolären (oberflächenvergrösserten) Typ wurde nur im oberen hinteren Recessus des Kiefergelenkes angetroffen, fibröses Synovialgewebe v.a. im oberen vorderen und im unteren hinteren Recessus. Synovialgewebe vom intermediären Typ fand man im unteren vorderen Recessus. Es gab keine strikten Grenzen zwischen artikulärem und synovialem Gewebe. Die Struktur und Kontinuität dieser Gewebsschichten deuten auf das Vorliegen eines zusammengehörigen Systems von Geweben- hier artikulär-synoviales Gewebe genannt-hin, das je nach Lokalisation und Funktion unterschiedliche histologische Gestalt annehmen kann. Die Autoren schlagen vor, alle auskleidenden Gewebe des Gelenkes als Synovialgewebe zu betrachten, dies aufgrund ihrer Eigenart der Nicht-Adhärenz.