# Temporomandibular Joint Structures: A Comparison Between Anatomic and Magnetic Resonance Findings in a Coronal and an Angulated Coronal Plane

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*Two temporomandibular joints from one specimen were investigated using magnetic resonance imaging and cryosectioning. Magnetic resonance images, photography of the tissue block surface, and on-tape histologic sections were compared. The left joint was imaged and sectioned in a coronal plane, and the right joint in an angulated coronal plane parallel to the long axis of the condyle. The temporomandibular joint disc could be seen in coronal and angulated coronal scans. The posterior band was imaged in angulated coronal magnetic resonance scans throughout the temporomandibular joint both medially and laterally. In coronal scans only parts of the disc proper could be seen, depending on the level of imaging or sectioning. The densely plaited fibrous tissue of the intra-articular tissues could be seen in magnetic resonance imaging, primarily anterior to the condyle; this tissue corresponded to the low signal intensity in magnetic resonance imaging. Medial and lateral disc attachments as well as the temporomandibular joint capsule were imaged in some of the magnetic resonance scans in both the coronal and the angulated coronal scans. In diagnosing anteromedial, medial, and lateral disc displacements, angulated coronal temporomandibular joint scanning is preferred over coronal scanning.*
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Magnetic resonance imaging (MRI) is used in diagnosing disc displacement of the temporomandibular joint (TMJ). Much emphasis has been given to anterior displacements, with and without reduction. However, mediolateral displacements also occur. The position of the TMJ disc proper with respect to the condyle and the mandibular fossa is used as an indicator of normal and altered disc position in the mediolateral direction. Normal disc position is described as a central position of the posterior band over the mandibular head.[1,2] In mediolateral displacements, the disc lies medially or laterally to the condyle (sideways displacement). Rotational displacements (anteromedial) are also described: laterally in the TMJ, the disc is displaced anteriorly; whereas on the medial side, this is not the case, or it is less pronounced. Gradations do also occur, explaining the variation in symptom profiles of patients with internal derangements.

A valid interpretation of the disc position requires a clear identification of the TMJ structures, especially the disc proper. An earlier study found that intra-articular tissues consisting of densely plaited fibrous tissue corresponded to the low signal intensity in MRI.[3] It was also found that angulated sagittal scanning is to be preferred over sagittal scanning. Coronal or angulated coronal scanning planes can be used to visualize the position and configuration of

the articular disc in the mediolateral direction (the angulated coronal plane is parallel to the long axis of the mandibular head).

The aim of this study was to see whether the correlations found in sagittal scanning could also be demonstrated in coronal scanning. Anatomical and MRI aspects of human TMJ structures were compared in a coronal and angulated coronal scanning plane, with emphasis on the disc proper.

## Materials and Methods

One undissected specimen (female, aged 85 years, complete denture wearer) was used for MRI and cryosectioning of the left TMJ in a coronal plane and of the right TMJ in an angulated coronal plane. The dentures were removed without changing the mandibular position. After decapitation, embalming was performed by perfusing 4% formaldehyde into the common carotid arteries, followed by immersion in the same fixative.

Magnetic resonance imaging of the left and right TMJ was performed with a Philips (Best, The Netherlands) T5 (0.5 Tesla) system. The specimen was oriented in the MR scanner in a position comparable to the normal supine position used for clinical patients. Both joints were imaged in the closed mouth position. A circular surface coil (8-cm diameter, receiver only) was positioned over the TMJ. A short spin echo (SE) T1-weighted transverse scout scan was used to identify the location of the TMJ. On the left side, coronal and sagittal series were acquired, with the following parameters: 3-mm slice thickness, 0.3-mm slice gap, SE 720/50/4 (TR/TE/NEX), and field of view (FOV) 110 mm. A relatively long TE was used in order to be able to minimize the FOV as much as possible. On the right side the same parameters were used: the angulation with the coronal plane was 28 degrees. A 256 × 256 scan matrix was used for the left joint and 205 × 256 for the right. Angulated sagittal scanning was performed to evaluate whether these scans of medial and lateral parts of the joint already indicated the location of the disc proper in a coronal plane.

After MR scanning, the head was frozen at –60°C and cut into halves using a band saw. Next it was rinsed in running tap water for several days. After impregnations in 0.5% and 1% carboxymethylcellulose (CMC) at 60 torr, the halves were frozen again by liquid nitrogen. Taking the MRI planes into account, the frozen tissue blocks were trimmed to obtain the correct mounting planes in the cryomicrotome and were subsequently embedded in 1% CMC. Then the undecalcified block was placed in the cryomicrotome at –20°C.

The thickness chosen for sectioning was 25 µm. Pictures of the surface block in the region of the TMJ and on-tape sections[4] were taken after every 0.5 mm of sectioning. The on-tape sections were stained with a modified Mallory-Cason procedure[4] and mounted on cardboard.

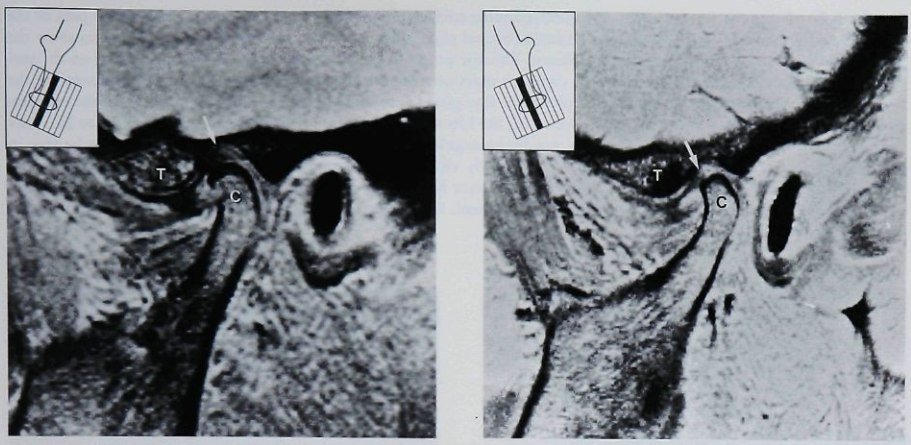
With the skin as a reference, calculations were made to determine which surface photograph and section corresponded with the MR image, taking into account the slice thickness, slice gap, and section interval. The choice of photographs and sections was checked by comparing them with the MR images.

Evaluation of the anatomic details in the region of the TMJ was carried out by determining the recognizability of relevant structures with regard to the condyle, intra-articular structures, the capsule, disc attachments, joint spaces, and the lateral pterygoid muscle. This was done on the MR images, photographs, and sections.

For recognition of the condyle, the intimate relation of the surface of the condyle and the intra-articular tissues had to be visible. In contrast to an earlier definition of the disc,[5] the bilaminar region was not included. Instead, "disc proper" was used to indicate the part of the intra-articular tissues consisting of densely plaited fibrous tissue.[3] Less-dense fibrous tissues outside the disc proper were defined as attachments. On MR images, the disc proper was characterized by low signal intensity; on surface photographs, by a whitish appearance; and on sections, by a compact mass of tissue. For recognition of the lateral and medial disc attachments, the connection to the disc proper had to be visible. On surface photographs and sections, these attachments were defined as the less-dense fibrous tissue lateral and medial to the disc proper, not representing the attachments to osseous structures themselves. On MR images, they were represented by the regions lateral and medial to the disc proper, showing higher signal intensity.

## Results

Angulated sagittal scans of the intra-articular TMJ tissues revealed that left/right differences were minimal (Figs 1a and 1b). Anatomic findings and corresponding MR images are shown in Figs 2a to 2f and 3a to 3f for the coronal and angulated coronal scan planes, respectively. The level of the slices through the joint is indicated by the shaded slices (insets).




**Figs 1a and 1b** Angulated sagittal MR scans of the left joint (left) and the right joint (right). The insets in the MR images show the parts of the joints involved and the scanning planes, projected on a superior view of the mandible. Left/right differences with respect to the position of the disc proper are minimal. (The arrows indicate the transitions from the disc proper to the bilaminar region. C = condyle, T = articular tubercle.)

Comparison of anatomic and MR findings of the condyle, disc proper, the lateral and medial disc attachments, the lateral capsule, and the attachment of the lateral pterygoid muscle to the disc proper are shown in Figs 4a to 4l for coronal and angulated coronal scan planes. The condyle and the disc proper were seen in more slices in both MRI and anatomy in the coronal scan plane compared to the angulated coronal scan plane. In the coronal scans (left TMJ) the condyle and the disc proper could be observed laterally in the anterior part of the joint, whereas the medial aspect was seen more posteriorly. Figures 4a, 4b, 4e, 4f, 4i, and 4j combine medial and lateral aspects; therefore, the posterior band is drawn in a more posterior position than it actually is. In the angulated coronal scan plane (right TMJ) the disc proper was simultaneously seen medially and laterally between the articular surfaces. The low signal intensity in the MR scans corresponded with the whitish appearance of the TMJ disc in surface photography and the compact mass of tissue in the sections in both scan directions. In the right TMJ (Figs 2d to 2f), the anterior sections showed the disc proper lying over the lower head of the lateral pterygoid muscle. At the central part (the widest mediolateral dimension of the condyle), only tissue of the bilaminar region tissue could be seen; tissue of the disc proper was absent (Figs 3d to 3f). In this right joint, the disc proper was positioned anterior to the summit of the condyle in line with the angulated sagittal scan findings. One of the sections through the left joint showed a disc configuration that resembled a sagittal section; in between a thick medial and lateral part of the disc proper a thin central part could be observed (Figs 5a to 5c). In MR this configuration could not be recognized.

The lateral attachment consisted of fibers running to the condyle (mandibular attachment) and to the temporal bone (temporal attachment) (see Figs 2 and 3). On the medial side of the left and right TMJ, the attachments of the disc proper ran into the lateral pterygoid muscle. Coronal scans showed the medial attachment. In the angulated coronal scans, the lateral disc attachment could be seen in one slice and the medial disc attachment was not recognizable (see Figs 4e, 4f, 4g, 4h).

The joint spaces could be imaged in both coronal and angulated coronal scans. The lateral pterygoid muscle appeared to attach to the articular disc over a long trajectory anteroposteriorly.

The lateral capsule wall could be recognized in both scan directions of MR. In the anterior part of both joints, MR showed a low signal intensity structure comparable to disc tissue (Figs 6a to 6c). This structure corresponded with the anterior extension of the TMJ disc, ie, the less dense fibrous tissue in front of the disc proper.

**Figs 2a to 2f** Magnetic resonance images, corresponding surface photographs, and sections of the anterior part of the TMJ coronal plane (Figs 2a to 2c) versus angulated coronal plane (Figs 2d to 2f). The insets in the MR images show the parts of the joint involved and the scanning planes. The disc proper is characterized by a whitish appearance on the surface photographs (Figs 2b and 2e) and by a compact mass of tissue on the sections (Figs 2c and 2f), representing the densely plaited fibrous tissue. In the coronal plane, the disc proper cannot be recognized in MR (Fig 2a). In the angulated coronal scan (Fig 2d), the disc correlates well with the low signal intensity. In the coronal plane (Figs 2b to 2c), only the lateral part of the disc proper can be seen, but in the angulated coronal plane (Figs 2d to 2f), the disc can be seen in its full mediolateral dimension. The condyle is only partly visible in the coronal MR scan (Fig 2a). The images in the angulated coronal plane show the disc lying over the inferior head of the lateral pterygoid muscle. (The arrows indicate the transitions from the disc proper to the lateral attachment. C = condyle, LPMi = inferior head of the lateral pterygoid muscle.)

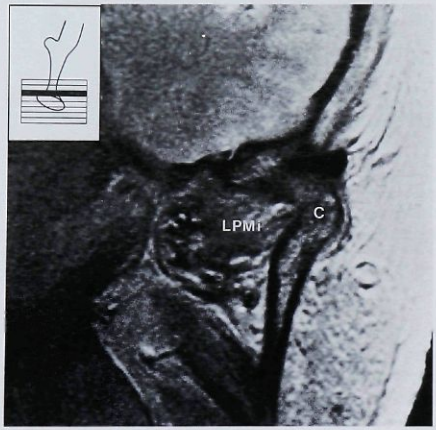



Fig 2a Magnetic resonance image of anterior part of TMJ in coronal plane.

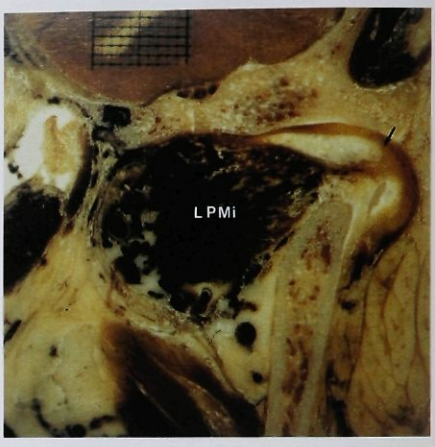



Fig 2b Corresponding surface photograph.

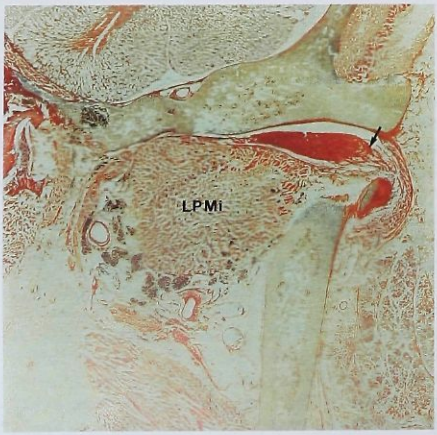



Fig 2c Corresponding section.

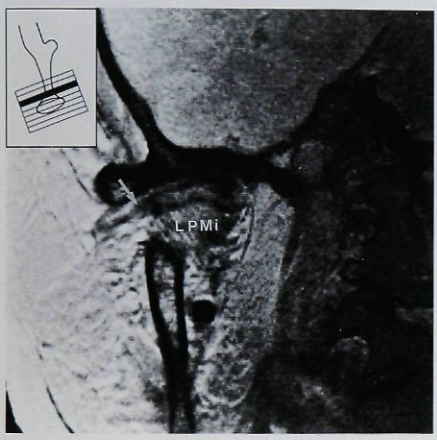



Fig 2d Magnetic resonance image of anterior part of TMJ in angulated coronal plane.

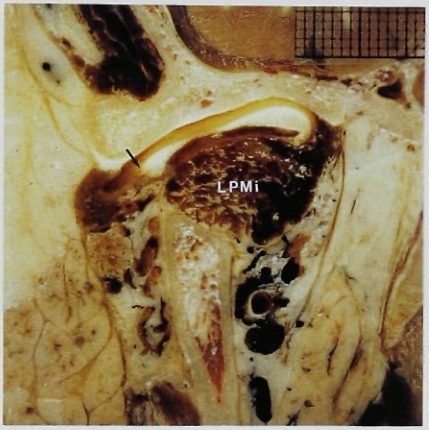



Fig 2e Corresponding surface photograph.


Fig 2f Corresponding section.

**Figs 3a to 3f** Magnetic resonance images, corresponding surface photographs, and sections in the central part of the TMJ coronal plane (Figs 3a to 3c) versus angulated coronal plane (Figs 3d to 3f). The insets in the MR images show the parts of the joint involved and the scanning planes. The disc proper is represented by the low signal intensity (Fig 3a), whitish appearance (Fig 3b), and compact mass of tissue (Fig 3c) in the coronal plane. Only the medial part is visible. In the angulated coronal plane (Figs 3d to 3f), the disc proper is absent; only tissue of the bilaminar region can be seen. (C = condyle, B = bilaminar region.)

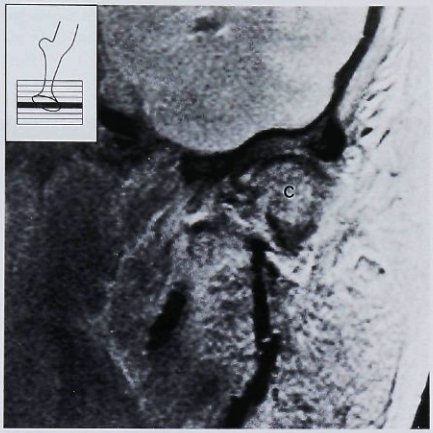



**Fig 3a** Magnetic resonance image of central part of TMJ in coronal plane.


**Fig 3b** Corresponding surface photograph.

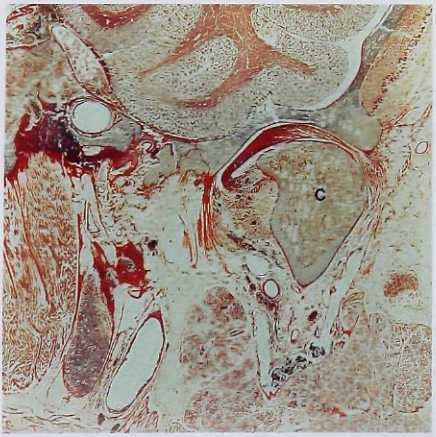



**Fig 3c** Corresponding section.

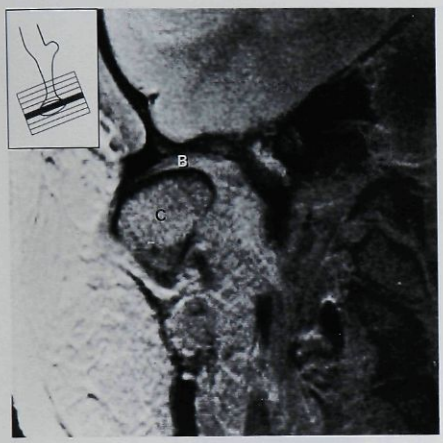



Fig 3d Magnetic resonance image of central part of TMJ in angulated coronal plane.

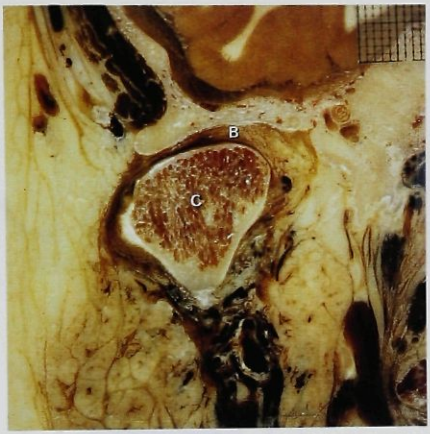



Fig 3e Corresponding surface photograph.

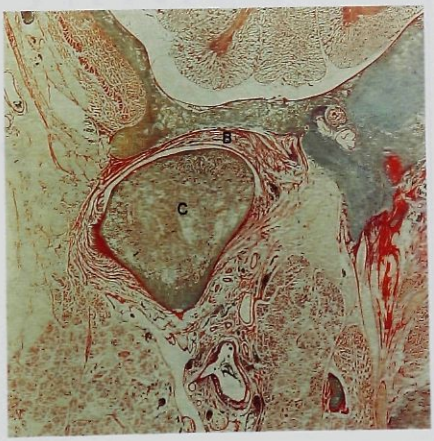
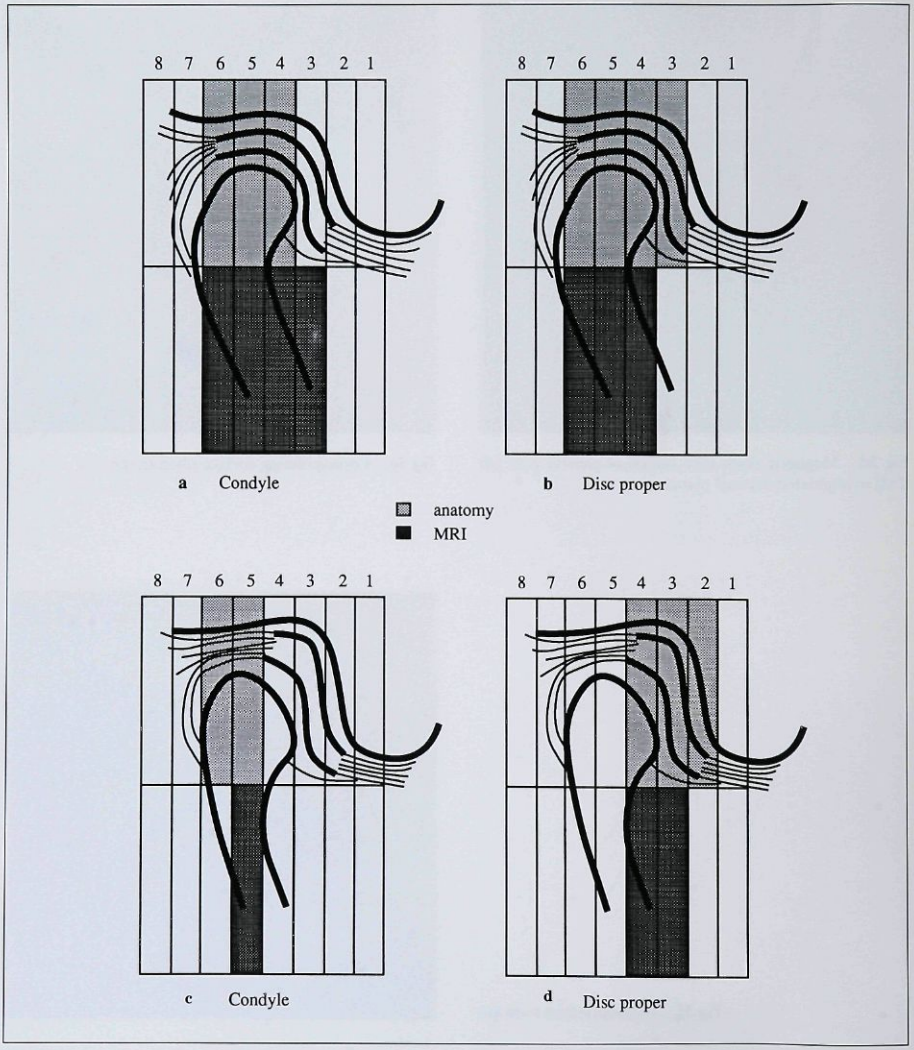


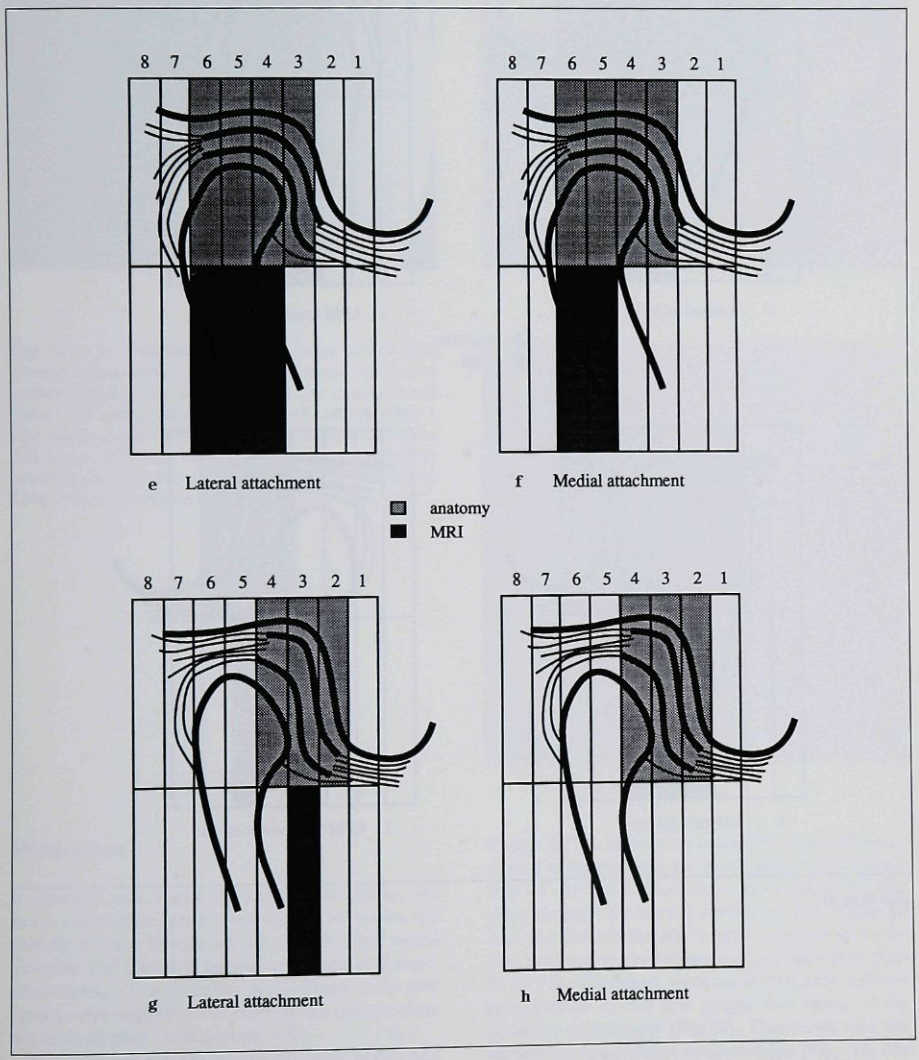

Fig 3f Corresponding section.

**Figs 4a to 4l** Results of the comparison of anatomic (ie, surface photographs and sections; light shading) and MR findings (dark shading) in the coronal plane (a, b, e, f, i, j) and in the angulated coronal plane (c, d, g, h, k, l). Shading represents recognizability of the structure involved in the slice concerned. The slices are projected on a medial view of the left joint (coronal plane) and on an anterolateral view, perpendicular to the long axis of the condyle, of the right joint (angulated coronal plane). The condyle (a, c) and the disc proper (b, d) are visible in more slices in the coronal plane than in the coronal angulated plane. The anatomic sections and MR images correlate well. The lateral attachment

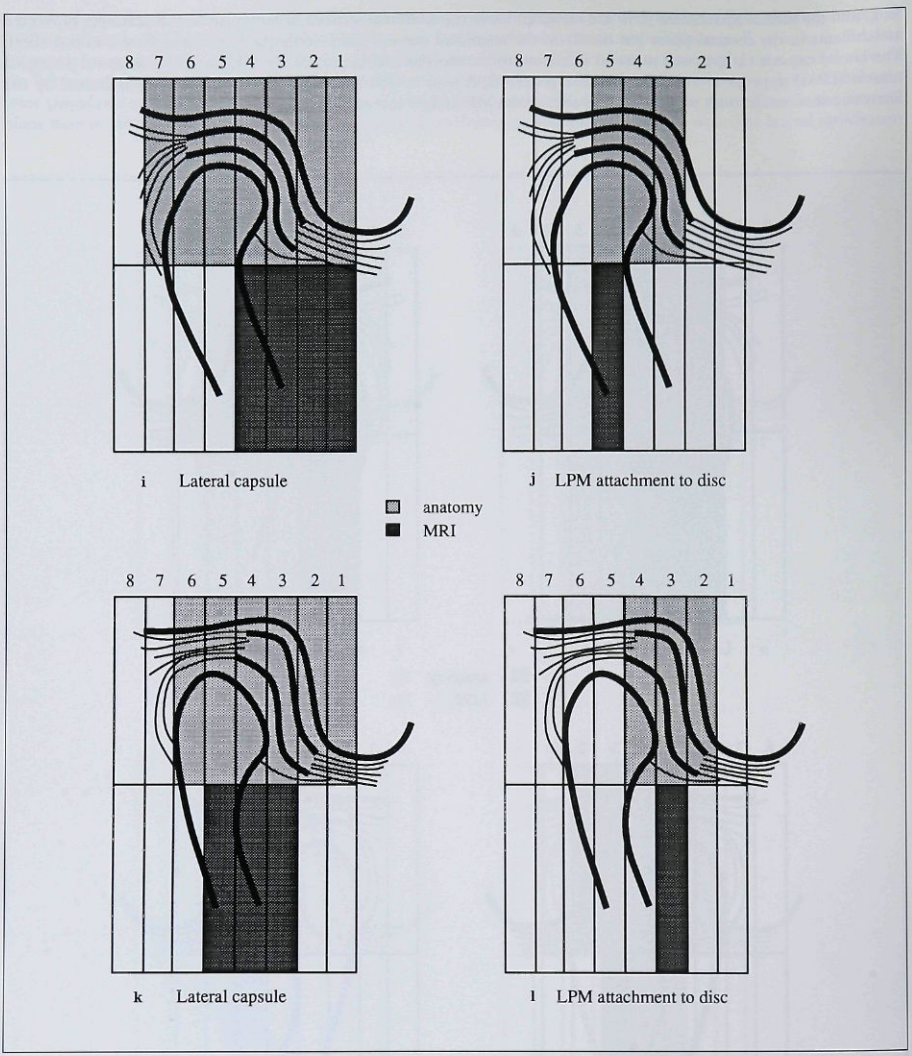



Figs 4a to 4d

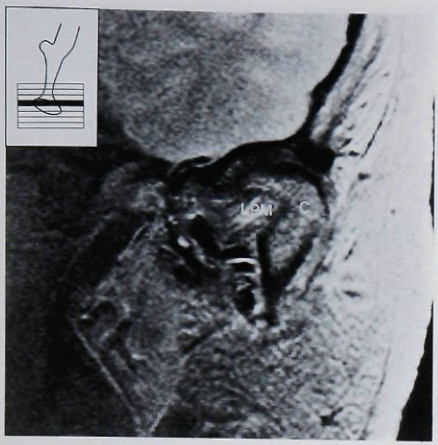
(e, g) and the medial attachment (f, h) are recognizable in the anatomic sections in both planes. MR scanning shows the attachments in the coronal plane but hardly in the angulated coronal plane (only the lateral attachment in one slice). The lateral capsule (i, k) is well depicted in the anatomic sections and in part of the MR images. The lateral pterygoid muscle (LPM) appears to attach to the disc proper (j, l) over its full anteroposterior dimension, as indicated by the anatomic sections. In both planes, just one slice of the MR images shows this attachment.

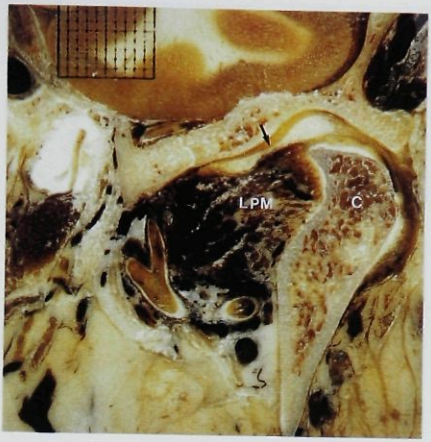


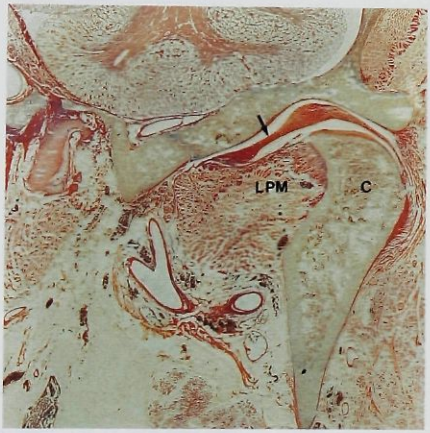

Figs 4e to 4h


8 7 6 5 4 3 2 1
i Lateral capsule
8 7 6 5 4 3 2 1
j LPM attachment to disc
anatomy
MRI
8 7 6 5 4 3 2 1
k Lateral capsule
8 7 6 5 4 3 2 1
l LPM attachment to disc

Figs 4i to 4l



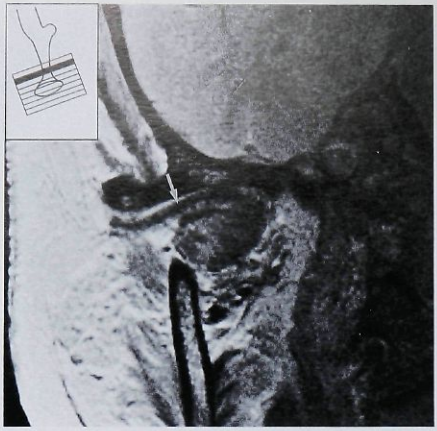



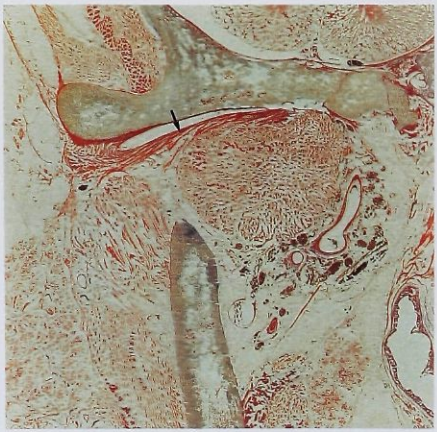

**Figs 5a to 5c** Magnetic resonance image *(above left)*, corresponding surface photograph *(above right)*, and section *(right)* in the central part of the joint; coronal plane. The surface photograph and the section show a disc configuration which cannot be recognized in the MR image. (The arrows indicate a thin central part in between thick medial and lateral parts. C = condyle, LPM = lateral pterygoid muscle.)

## Discussion

In coronal and angulated coronal scanning, the same correspondence was found between the densely plaited fibrous tissues and the low signal intensity also found in sagittal and angulated sagittal scanning.[3] The direction of the fibers in the disc proper with regard to the field of the magnet does not seem to play an important role.

The coronal or angulated coronal plane has been described as the most difficult plane with which to produce good-quality MR images of the TMJ.[6] As an explanation for this phenomenon, partial volume effects are mentioned, due to geometry of the joint. Another reason might be that slices through the medial and lateral pole image an area just behind the disc proper, depending on the disc position in the anteroposterior direction (Figs 7a to 7d). Therefore, imaging of this area will not reveal tissue of the disc proper but tissue of the posterior attachment (Fig 7c). This holds true for normal intra-articular relationships (Fig 7a), but even more for situations in which the disc is in a more anterior position (Fig 7b), in which it may be





**Figs 6a to 6c** Magnetic resonance image *(above left)*, corresponding surface photograph *(above right)*, and section *(left)* in the anterior part of the joint; angulated coronal plane. The low signal intensity (arrow) in the MR image is confusing. The surface photograph and section demonstrate that the low signal intensity corresponds with the less dense fibrous tissue of the anterior extension (arrows).

impossible to relate the position of the disc proper to the condyle (Fig 7d). In sideways displacements, the disc proper lies medially or laterally to the condyle, leading to images in which both condyle and the disc proper can be recognized. In normal joints and in disc displacements, it is not always possible to obtain a coronal image in which both condyle and disc proper are clearly visible; it depends on the relation in the angulated sagittal plane between the disc proper and the condyle and on the kind and the degree of displacement. Used with angulated coronal plane images, angulated sagittal scanning with enough slices in the medial and lateral parts of the joint may be helpful in assessing the disc position.

Because of the angle between the long axis of the condyle and the sagittal plane, lateral aspects are seen first in the anterior region of the TMJ in coronal images, eventually mimicking a rotational displacement. In line with the findings of other authors,[7] we concluded that angulated coronal scan planes are therefore preferred over coronal planes.

Fewer slices run through the condyle disc complex in coronal and angulated coronal scanning

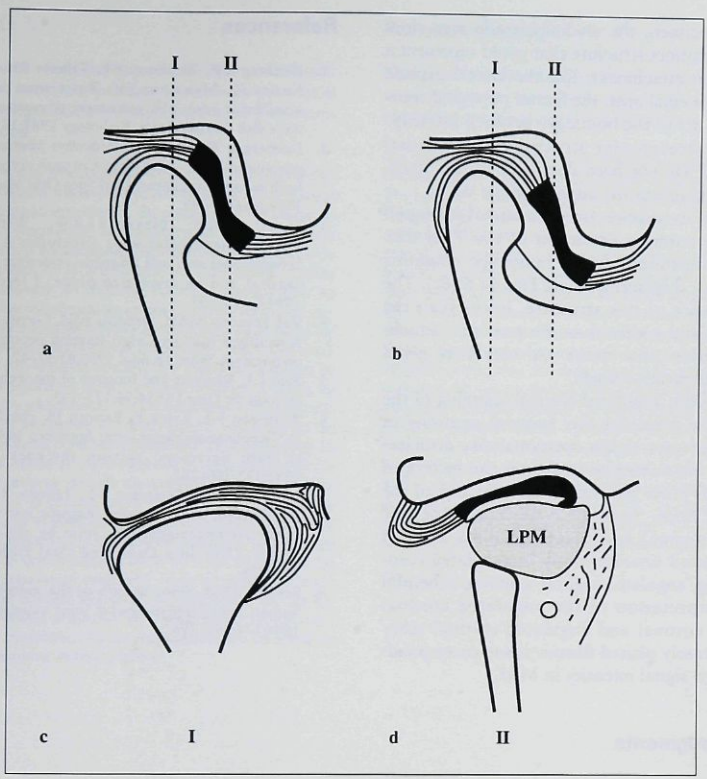



Fig 7 *(a)* Drawing of cross section of TMJ in angulated sagittal plane. The disc proper is shaded black. The intra-articular relationships represent a normal variant in which the posterior band is not in a central position over the mandibular head. *(b)* Same cross section as *(a)*, but with the disc proper in an even more anterior position. *(c)* Drawing of cross section in angulated coronal plane on the level of plane I of *(a)* and *(b)*, through the condyle. This section shows the fibrous tissue of the bilaminar region, not the denser tissue of the disc proper. *(d)* Cross section in the same plane as *(c)* on the level of plane II of *(a)* and *(b)*. The disc proper, revealed in its full mediolateral dimension, can be seen lying over the lateral pterygoid muscle (LPM), and its position cannot be related to the condyle.

than in sagittal scanning, because of the smaller anterior/posterior dimensions. Since coronal scanning is not perpendicular to the long axis of the condyle, the condyle and disc proper can be seen in more scans of this direction than in angulated coronal scans. In the angulated coronal scans, the disc is found in a relatively small number of slices. This is even more the case in joints with a steep tubercle.

In one of the angulated coronal scans (see Fig 4c), the condyle is unexpectedly not recognized in MR or in anatomy because of the definition of condylar recognition. The intimate relation of the articular surfaces of the condyle and the intra-articular tissues should be visible. The attachment of the lateral pterygoid muscle to the pterygoid fovea is seen; the contour of the condyle is not yet visible as it is in Figs 3d to 3f (3.5 mm more posteriorly).

In our specimen, the medial capsule area does not show a distinct structure that could represent a capsule or an attachment, like the lateral capsule wall. In this medial area, the lateral pterygoid muscle seems to act as the boundary between intracapsular and extracapsular structures. The medial capsule wall has not been described in the literature as extensively as the lateral capsule wall.[8]

Because of its position over the lateral pterygoid muscle, the anterior extension of the TMJ disc may have contributed to the radiologic diagnosis of an anterior displacement (see Figs 6a to 6c). The signal intensity of this structure, lower than the disc proper and higher than the posterior attachment, resembled disc tissue and may have given rise to a false positive result.

In conclusion, angulated coronal scanning of the TMJ is to be preferred over coronal scanning in detecting sideways and/or rotational disc displacements. The intra-articular structures can be judged better in this plane parallel to the long axis of the mandibular head. Since the condyle and the disc proper of normal and displaced discs are not always depicted simultaneously in angulated coronal scanning, angulated sagittal scanning is helpful in the interpretation of the angulated coronal images. In coronal and angulated coronal scanning, the densely plaited fibrous tissue corresponded to the low signal intensity in MRI.

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## References

1. Katzberg RW, Westesson P-L, Tallents RH, Anderson R, Kurita K, Manzione JV, Totterman S. Temporomandibular joint: MR assessment of rotational and sideways disk displacements. Radiology 1988;169:741–748.
2. Liedberg J, Westesson P-L. Sideways position of the temporomandibular joint disk: Coronal cryosectioning of fresh autopsy specimens. Oral Surg Oral Med Oral Pathol 1988;66:644–649.
3. Steenks MH, Bleys RLAW, Witkamp TD. Temporomandibular joint structures: A comparison between anatomic and magnetic resonance findings in a sagittal and an angulated plane. J Orofacial Pain, 1994;8:120–135.
4. Van Leeuwen MBM, Deddens AJH, Gerrits PO, Hillen B. A modified Mallory-Cason staining procedure for large cryosections. Stain Technol 1990;65:37–42.
5. Rees LA. Structure and function of the temporomandibular joint. Br Dent J 1954;96:125–133.
6. Westesson P-L, Kwok E, Barsotti JB, Hatala M, Paesani D. Temporomandibular joint: Improved MR image quality with decreased section thickness. Radiology 1992;182:280–282.
7. Musgrave MT, Westesson P-L, Tallents RH, Manzione JV, Katzberg RW. Improved magnetic resonance imaging of the temporomandibular joint by oblique scanning planes. Oral Surg Oral Med Oral Pathol 1991;71:525–528.
8. Savalle WPM. Some aspects of the morphology of the human temporomandibular joint capsule. Acta Anat 1988;131:292–296.

## Resumen

Las estructuras de la articulación temporomandibular: Comparación entre los hallazgos anatómicos y los de la resonancia magnética en planos coronales y en coronales angulados

Se investigaron dos articulaciones temporomandibulares (ATM) de un espécimen por medio del uso de imágenes de resonancia magnética y crioseccionamiento. Se compararon las imágenes de resonancia magnética, la fotograffa de la superficie del bloque de tejido, y las secciones histológicas en existencia. Se tomaron imágenes de la articulación del lado izquierdo; ésta luego fue seccionada en un plano coronal. La articulación del lado derecho fue seccionada en un plano coronal angulado, paralelo al eje longitudinal del cóndilo. El disco de la ATM podía ser visto en imágenes exploratorias coronales y coronales anguladas. Se visualizó la banda posterior por medio de imágenes de resonancia magnética en sentido coronal angulado a través de la ATM, interna y lateralmente. En los escáneres coronales sólo se pudieron ver las partes del disco propio, dependiendo del nivel de las imágenes o del seccionamiento. En las imágenes de resonsncia magnética se pudo visualizar la parte fibrosa de los tejidos intra-articulares plegada densamente, principalmente en la parte anterior al cóndilo; este tejido correspondió con la intensidad baja de la señal en las imágenes de resonancia magnética. Se visualizaron las inserciones medias y laterales del disco, lo mismo que la cápsula de la ATM en algunos de los escáneres de resonancia magnética, tanto en el escáner coronal como en el coronal angulado. Se prefiere el uso de los escáneres coronales angulados en comparación con los coronales, para el diagnóstico de los desplazamientos de disco en sentido anterointerno, interno y lateral.



## Zusammenfassung

Kiefergelenkstrukturen: Ein Vergleich zwischen anatomischen und Magnetresonanzbefunden in koronalen und gekippten koronalen Ebenen

Die zwei Kiefergelenke einer Person wurden per MRI und Gefrierschnitte untersucht. Es wurden Magnetresonanzbilder, Photographien und histologische Schnitte verglichen. Das linke Gelenk wurde in der Koronalebene abgebildet und geschnitten, das rechte Gelenk in einer korrigierten koronalen Ebene d. h. parallel zur Längsachse des Kondylus. Der Kiefergelenksdiskus konnte in beiden Aufnahmen gesehen werden. Das hintere Band wurde in den korrigierten koronalen Schnitten durch das ganze Gelenk hindurch sowohl medial als auch lateral dargestellt. Bei den koronalen Schnitten konnten nur Teile des Diskus gut gesehen werden, abhängig von der Ebene der Bildgebung oder des Schnittes. Das dicht geflochtene fibröse Gewebe der intraartikulären Weichgewebe konnte in den Magnetresonanzaufnahmen vor allem anterior des Kondylus gesehen werden; dieses Gewebe entsprach der niedrigen Signalintensität im Magnetresonanzbild. Das mediale und laterale Attachment des Diskus und die Kiefergelenkskapsel wurden in einigen der koronalen und der korrigierten koronalen Schnitte dargestellt. Zur Diagnose von anteromedialen, medialen und lateralen Diskusverlagerungen soll die korrigierte Darstellung der rein koronalen vorgezogen werden.