RESEARCH

Synovial chondromatosis of the temporomandibular joint: MRI findings with pathological comparison

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Objectives: The aim of this retrospective study was to characterize MRI findings of synovial chondromatosis in the temporomandibular joint (TMJ) by correlation with their pathological findings.

Methods: 22 patients with synovial chondromatosis in unilateral TMJ were referred for plain MRI prior to surgical management and pathological examinations. Parasagittal and coronal proton density-weighted imaging and T_2 weighted imaging were performed for each case.

Results: MRI demonstrated multiple chondroid nodules and joint effusion in all patients (100%) and amorphous iso-intensity signal tissues within expanded joint space and capsule in 19 patients (86.4%). On T_2 weighted imaging, signs of low signal nodules within amorphous iso-intensity signal tissues were used to determine the presence of attached cartilaginous nodules in pathology, resulting in 100% sensitivity, 60% specificity and 90.9% accuracy. Signs of low and intermediate signal nodules within joint fluids were used to detect loose cartilaginous nodules and resulted in 80% sensitivity, 42.9% specificity and 68.2% accuracy.

Conclusions: MRI of synovial chondromatosis in TMJ was characterized by multiple chondroid nodules, joint effusion and amorphous iso-intensity signal tissues within the expanded space and capsule. The attached cartilaginous nodules in pathology were better recognized than the loose ones on MRI. Plain MRI was useful for clinical diagnosis of the disorder.

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Introduction

Synovial chondromatosis is defined by the World Health Organization¹ as a benign nodular cartilaginous proliferation arising from the joint synovium, bursae or tendon sheaths. The condition of the primary growth characteristics and locally destructive behaviour suggest a neoplasm.¹ Although the temporomandibular joint (TMJ) is infrequently affected by a tumour or tumour-like lesion, synovial chondromatosis is the most common neoplastic lesion of the joint.² Evaluations of TMJ

synovial chondromatosis by using CT and MRI have been frequently reported in the literature.^{2–14} However, an integrated depiction of MRI features on this condition based on the correlation with pathological findings was not seen in previous reports owing to few patients and variations of MRI sequences and planes.

Pathologically, synovial chondromatosis is characterized by the multiple cartilaginous nodules or bodies formed in the synovial membrane. The multiple cartilaginous bodies or nodules may be either covered (attached) or uncovered (detached) by the synovial lining cells and fibrous tissues.¹ A correct differentiation between both cartilage bodies or nodules is helpful in reducing recurrence rate after a synovectomy, especially during the early phase of the disease.¹

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The purpose of the current study was to characterize MRI findings of TMJ synovial chondromatosis and determine the capabilities of common MRI sequences in the assessment of covered and uncovered cartilage bodies in the disorders.

Materials and methods

From 2003 to 2009, 22 patients with unilateral synovial chondromatosis underwent surgical therapy after MRI in the Ninth People's Hospital, School of Medicine, Shanghai Jiao Tong University, Shanghai, China. All patients were histopathologically confirmed and retrospectively reviewed. The patients included 15 females and 7 males, ranging in age from 17 years to 64 years, with a mean age of 45.3 years (Table 1).

TMJ MRI was performed on a 1.5 T Signa TwinSpeed system (GE Healthcare, Milwaukee, WI) by using the dual TMJ array coil. In the closed mouth position, both oblique sagittal and coronal slices were obtained with proton density-weighted imaging (PDWI) fast spin-echo sequence. The parameters of PDWI were as follows: time of repetition (TR)/time of echo (TE), 1360–2000/20–26 ms; 3 acquisitions; field of view (FOV), 10 × 10 cm; bandwidth, 31.2 Hz; matrix, 320 × 192; slice thickness, 2 mm (oblique sagittal) and 1.5 mm (oblique coronal); spacing, 1 mm (oblique sagittal) and 0.5 mm (oblique coronal). In the open mouth position, oblique sagittal images were obtained with T_2 weighted imaging (T_2 WI) fast spin-echo sequence. The parameters of T_2 WI were as follows: TR/TE, 3760–4300/82–90 ms; 3 acquisitions; FOV, 10 × 10 cm; bandwidth, 31.2 Hz; matrix, 320 × 192; slice thickness, 2 mm; spacing, 1 mm.

MR images of 22 patients were independently reviewed by 3 radiologists who were blinded to the pathological reports and the final interpretations of the MRI findings of the synovial chondromatosis in a TMJ were based on a consensus of at least 2 of the radiologists. The described parameters on MRI for each subject comprised (1) internal structural change of synovial chondromatosis, (2) contour change of joint space and capsule and (3) change of glenoid fossa of temporal bone and mandibular condyle. Contralateral TMJ of each subject was used as an internal comparison. The observed items on surgical procedures and pathological findings for each subject included (1) cartilage nodules attached to the synovium and fibrous tissues (synovial metaplasia) and (2) cartilage nodules detached to the synovium and fibrous tissues (loose cartilage bodies). The sensitivities, specificities and accuracy of MRI in determining both cartilage bodies were calculated.

Results

The surgical procedures and pathology confirmed that of 22 patients, 20 (90.9%) lesions originated from the

superior space, 1 (4.5%) lesion from the inferior space and 1 (4.5%) from both spaces of the TMJ. There were no extracapsular soft-tissue involvements which were proven by pathology and MRI in all subjects. The sex, age, location and abnormal MRI findings for each case are listed in Table 1.

The abnormal MRI findings of TMJ synovial chondromatosis included: (1) joint effusion (Figures 1–4) in all patients; (2) multiple nodules within the joint space (Figures 1–4) in all patients; (3) amorphous iso-intensive signal tissues to joint fluids and calcified nodules on T_2 WI within the expanded joint space and capsule (Figures 2–4) in 19 patients (86.4%); (4) erosion of the glenoid fossa of temporal bone (Figure 2) in 5 patients (22.7%); and (5) erosion of the mandibular condyle (Figure 4) in 2 patients (9.1%).

The multiple chondroid nodules appeared in punctuate form in 20 (90.9%) patients and spherical ring-like forms in 11 (50%) patients. Amorphous iso-intensity signal tissues within the expanded joint space and capsule on T_2 WI (Figures 2–4) were mainly composed of uncalcified or unossified hyaline cartilage nodules in pathology, which were either covered or uncovered by the synovial tissues and fibrous tissues. 3 out of 22 patients (13.6%) were without the amorphous iso-intensive signal structures and expanded joint space and capsule (Figure 1). Skeleton erosion of the mandibular condyle was only seen in patients with lesions involved in the inferior space of the TMJ (Figure 4), while erosion of the glenoid fossa of the temporal bone was only visible in patients with lesions in the superior space of the TMJ (Figure 2).

On the basis of the relationship among low and iso-intensity signal nodules, joint effusion and iso-intensity signal tissues shown on T_2 WI, two MRI signs were noticed: low signal nodules within intermediate intensive signal tissues (19 patients, 86.4%, Figures 2–4) and low and iso-intensity signal nodules within high signal joint effusion (16 patients, 72.7%, Figure 1). If both MRI signs represented attached and loose cartilage nodules in pathology respectively, the correlations between MRI and pathological findings for each case are seen in Table 2. The diagnostic values of both MRI signs in determining the correlation with pathological findings are listed in Table 3.

Discussion

Synovial chondromatosis was considered a rare condition of the TMJ in the past. Recently, reports on the disease have been increased owing to the development of new imaging modalities, including CT and MRI, which dramatically improved the capabilities in the diagnosis of bone and joint diseases.^{2–14} MRI appearances of TMJ synovial chondromatosis included joint effusion, multiple chondroid nodules or bodies, proliferative synovium, expanded joint capsule, anterior displacement of the mandibular condyle and intracranial

Table 1 Sex, age, location and MRI findings of temporomandibular joint synovial chondromatosis in 22 cases

<i>No. of case</i>	<i>Sex/age (years)</i>	<i>Left/right</i>	<i>Superior space</i>	<i>Inferior space</i>	<i>Joint fluids</i>	<i>Low and intermediate signal nodules</i>	<i>Amorphous iso-intensity signal tissues on T₂ weighted images</i>	<i>Expanded joint space and capsule</i>	<i>Condyle erosion</i>	<i>Glenoid fossa erosion</i>
1	F/42	L	+	—	+	+	+	+	—	—
2	F/45	L	+	—	+	+	+	+	—	—
3	F/48	L	+	—	+	+	+	+	—	—
4	M/42	R	+	—	+	+	+	+	—	—
5	M/27	L	+	—	+	+	+	+	—	+
6	F/42	L	+	—	+	+	—	—	—	—
7	F/53	L	+	—	+	+	+	+	—	—
8	F/17	R	+	—	+	+	—	—	—	—
9	M/38	R	+	—	+	+	+	+	—	+
10	F/40	R	+	—	+	+	+	+	—	—
11	F/45	L	+	—	+	+	+	+	—	—
12	M/63	L	+	—	+	+	+	+	—	—
13	F/61	R	+	—	+	+	—	—	—	—
14	M/41	R	+	+	+	+	+	+	+	—
15	M/64	L	+	—	+	+	+	+	—	+
16	F/46	R	+	—	+	+	+	+	—	—
17	F/51	R	+	—	+	+	+	+	—	—
18	F/48	L	+	—	+	+	+	+	—	+
19	M/57	R	+	—	+	+	+	+	—	+
20	F/44	R	—	+	+	+	+	+	+	—
21	F/45	R	+	—	+	+	+	+	—	—
22	F/38	R	+	—	+	+	+	+	—	—

F, female; L, left; M, male; No., number; R, right; +, positive; —, negative.

Figure 1 Synovial chondromatosis in the right temporomandibular joint (TMJ) (patient 8). Sagittal (a) proton density-weighted imaging in closed mouth position and (b) T_2 weighted imaging (T_2 WI) in open mouth position show the lesion in unexpanded upper joint space of the TMJ. The multiple ovoid chondroid nodules (white arrow) are within high signals of joint effusion on T_2 WI. (c) Pathological figure with haematoxylin-eosin stain (original magnification $\times 12.5$) shows the loose calcified nodules in the lesion

involvement. However, an appropriate correlation between MRI and pathological findings on the condition was usually seen in case reports.^{5,7-10} In the current study, the authors not only characterize MRI findings of the disease based on the numerous cases but also compare the MRI findings with surgical and pathological outcomes.

TMJ synovial chondromatosis has frequently occurred in the upper compartment of the TMJ,^{2,11,13} which could lead to expansion of the joint space or capsule^{2,4-6,9,11} and intrajoint fluid collections.^{2,4-6,11,13} The data from the current study supported these findings. In addition, close relationships between expanded joint capsule and lesion contents, including joint effusion, metaplastic synovium containing attached cartilage nodules and loose cartilage nodules, were noticed. We found that the more effusion, metaplastic synovium and chondroid nodules accumulated in the joint space, the more expansion there was in the joint space and capsule.

On MRI, TMJ synovial chondromatosis is characterized by multiple chondroid nodules with low and iso-intensity signals within the joint space. The low signal intensity nodules might appear as both small round and punctuate forms, which correlated with calcified and ossified ones in pathology. Meng *et al*¹³ described some spherical cartilaginous bodies as a “ring-like” form and deemed that this sign is a MRI feature of TMJ synovial chondromatosis. The iso-intensity signal nodules were only shown on T_2 WI, which often appeared as a punctuate form under the background of high signal joint effusion in our series. Our study indicated that both punctuate and spherical ring-like chondroid nodules might appear in the same lesion. The spherical ring-like nodules only occurred in 50% of the patients in this study and were less frequently visible than punctuate nodules.

Amorphous intermediate signal structures to low signal cartilaginous nodules and high signal joint effusion within the expanded joint spaces or capsules

Figure 2 Synovial chondromatosis in the right temporomandibular joint (TMJ) (patient 9). Sagittal (a) proton density-weighted imaging in closed mouth position and (b) T_2 weighted imaging (T_2 WI) in open mouth position show the lesion in expanded upper joint space (white arrowheads) of the TMJ, accompanied erosion of glenoid fossa of temporal bone. There are low signal nodules within amorphous iso-intensity signal tissues (white arrow) and high signal fluids on T_2 WI. (c) Pathological figure with haematoxylin-eosin stain (original magnification $\times 400$) shows the multiple hyaline cartilage nodules with local calcification (black arrow) and fibrous connective tissues

Figure 3 Synovial chondromatosis in the right temporomandibular joint (TMJ) (patient 22). Sagittal (a) proton density-weighted imaging and (b) T_2 weighted imaging (T_2 WI) in closed mouth position show the lesion located in expanded superior space (white arrowheads) of the TMJ. The low signal nodules within amorphous iso-intensity signal structures (white arrow) and high signal joint effusion are seen on T_2 WI. (c) Pathological figure with haematoxylin-eosin stain (original magnification $\times 400$) shows the multiple hyaline cartilage nodules with lack of calcification and ossification covered by the hyaline fibrous tissues

on T_2 WI were found in most subjects in the current study. In comparison with pathological findings we found that the irregular intermediate signal tissues were mainly composed of uncalcified and unossified nodules, which were attached to and detached from synovial and fibrous tissues. Murphey *et al*¹⁵ considered that nodules with intermediate signal intensity characteristics reflected the high water content of the cartilaginous bodies.

On the basis of the relationship among joint effusion, amorphous iso-intensity signal tissues and low and iso-intensity signal nodules shown on T_2 WI, two MRI signs were noticed in the current study. One was low signal nodules within the amorphous intermediate signal tissues and the other was low and iso-intensity signal nodules within the high signal joint effusion. Both signs were not emphatically described in the previous literatures. The authors of this study assumed that both MRI signs represented the attached cartilaginous nodules and loose cartilaginous nodules in

surgical pathology, respectively. The accuracy of both MRI signs in determining attached cartilaginous nodules and loose cartilaginous nodules in pathology were 90.9% and 68.2%, respectively. The different accuracy between both MRI signs indicated that the capability of MRI in detecting the attached cartilaginous nodules was superior to the loose ones in TMJ synovial chondromatosis. In the current study, we found that a correct match between MRI findings and pathological findings was established in 13 of 22 (59%) patients. The main reasons for mismatch may be that in plain MRI it is difficult to discriminate the amorphous intermediate signal tissues on T_2 WI as the tissues may be either uncalcified and unossified chondroid nodules or synovial and fibrous tissues.

TMJ synovial chondromatosis with erosion of the glenoid fossa and condyle shown on CT and MRI has been reported.^{3,12,14} In the current study, signs of destruction of the glenoid fossa were only visible in the patients involving the superior space of the TMJ,

Figure 4 Synovial chondromatosis in the right temporomandibular joint (TMJ) (patient 20). (a) Sagittal T_2 weighted imaging (T_2 WI) shows the lesion located in expanded inferior space of the TMJ. The amorphous intermediate signal tissues (white arrowhead), low signal nodules (white arrow) and small amount of high signals effusion are seen on T_2 WI. (b) Coronal proton density-weighted imaging in closed mouth position shows the expanded inferior space and joint capsule of right TMJ, and erosion of mandibular condyle (white arrow). (c) Pathological figure with haematoxylin-eosin stain (original magnification $\times 100$) shows the multiple hyaline cartilage nodules (black arrow) on the surface of the mandibular condyle (white star), which attached to the synovial lining cells

Table 2 The match between pathological findings and MRI signs in temporomandibular joint synovial chondromatosis of 22 cases

No. of case	Pathological findings		MRI findings		Match between pathological findings and MRI findings
	Chondroid nodules attached to synovium	Loose chondroid nodules	Sign 1	Sign 2	
1	+	+	+	—	No
2	+	+	+	+	Yes
3	+	+	+	+	Yes
4	—	+	+	+	No
5	+	+	+	—	No
6	—	+	—	+	Yes
7	+	—	+	+	No
8	—	+	—	+	Yes
9	+	—	+	+	No
10	+	+	+	+	Yes
11	+	+	+	+	Yes
12	+	—	+	—	Yes
13	—	+	—	+	Yes
14	+	+	+	+	Yes
15	+	+	+	+	Yes
16	—	+	+	+	No
17	+	+	+	—	No
18	+	—	+	+	No
19	+	—	+	+	No
20	+	—	+	—	Yes
21	+	+	+	+	Yes
22	+	—	+	—	Yes

No., number; +, positive; —, negative.

Sign 1: low signal nodules within amorphous iso-intensity signal tissues.

Sign 2: low and intermediate signal nodules within joint fluids.

Table 3 MRI value in judging attached and detached condroid nodules in temporomandibular joint synovial chondromatosis of 22 cases

MRI findings	True positive	True negative	False positive	False negative	Sensitivity	Specificity	Accuracy	Positive predictive value	Negative predictive value
Sign 1	17	3	2	0	100%	60%	90.9%	89.5%	100%
Sign 2	12	3	4	3	80%	42.9%	68.2%	75%	50%

Sign 1: low signal nodules within amorphous iso-intensity signal tissues.

Sign 2: low and intermediate signal nodules within joint fluids.

Sensitivity = true positive / true positive + false negative.

Specificity = true negative / true negative + false positive.

Accuracy = true positive + true negative / total.

Positive predictive value = true positive / true positive + false positive.

Negative predictive value = true negative / true negative + false negative.

whereas signs of condyle erosion were only visible in the patients involving the inferior space of the TMJ. The phenomena were compatible with the descriptions from Ida *et al.*¹² We assume that a corresponding relationship between the lesion site (superior or inferior space of the TMJ) and the location of TMJ bone erosion (glenoid fossa or condyle) may exist. The TMJ synovial chondromatosis with involvement of intracranial structures, such as dura and temporal lobe of the cerebrum, was even rarer owing to self-limiting growth of this disorder. However, this bony erosion may be an

important indication that lesions will develop towards the intracranial structures.

In conclusion, MRI features of TMJ synovial chondromatosis mainly include the multiple cartilaginous nodules, joint effusion and amorphous iso-intensity signal tissues in the expanded space and capsule. The attached cartilage nodules in pathology may be better recognized on MRI than the loose cartilage nodules. MRI findings could be used to diagnose and classify approximately two thirds of the patients with TMJ synovial chondromatosis.

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