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Diagnosis and management of temporomandibular joint synovial chondromatosis: A systematic review

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A R T I C L E I N F O

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A B S T R A C T

The aim of this study was to systematically review the diagnosis and management of temporomandibular joint synovial chondromatosis (TMJ-SC). Using a systematic study design based on the PRISMA guideline, the researchers implemented and analyzed a cohort of relevant publications indexed by PubMed, Embase, Medline, and LILACS between January 1990 and December 2022. The outcomes of interest were demographics of the primary studies, and Clinical, radiological, and therapeutic data associated with TMJ-SC. The study samples included 8 studies presenting 121 TMJ-SC cases (73.6% female; 100% unilateral; 53.7% left-sided; mean age, 43.3 ± SD 5,80 [range, 21–81]. Non-specific symptoms were mostly reported, including TMJ pain, noise and local inflammation, and/or malocclusion. Radiographically, loose bodies, masses with low-signal foci, and calcification were common charateristics. Until now, there has been no internationally accepted consensus on diagnosis and management of TMJ-SC. Arthroscopic surgery should be performed on masses confined to the superior TMJ space, while open arthroplasty is indicated in cases with the extra-articular extension. A combination of both treatment methods may be necessary, when the lesion locates extending beyond the medial groove of the condyle.

1. Introduction

Temporomandibular Synovial chondromatosis (TMJ-SC) is cartilaginous metaplasia that destroys synovial membranes in the joints. Initially described in 1933, as a very rare entity (Auxhausen G, 1933). The cartilaginous nodules found on the synovial tissue can pedunculate and be detached from the synovial membrane, becoming free bodies within the joint space with different histological stages according to Milgram classification (Milgram JW, 1977). Although TMJ-SC is a benign tumor lesion, if not treated, it can be invasive, even extending to the intracranial fossa (Daspit and Spetzler, 1989). In addition, it can easily reappear, so the evaluation of the involved area before surgery is important to decide on surgical methods (Chen et al., 2015). Patients usually present with very non-specific symptoms, which is why images provide the clinician with the most valuable information. If misdiagnosed, the pathology spreads to difficult-to-access areas and the symptoms persist.

Late diagnosis or misdiagnosis is common due to nonspecific symptoms and low incidence (Lucas et al., 1997). Diagnosis is made with magnetic resonance imaging (MRI) and computed tomography (CT). MRI can identify TMJ-SC at an early stage by detecting the tissue response to this condition (Von Lindern et al., 2002). In addition, it helps to observe the joint space and the anatomical extension. In this way, it is important for the surgeon to know the different characteristics that can be identified in the images and likewise diagnose the disease early or treat it according to its stage. Unfortunately, there is no guide for readers to help them define the most appropriate therapeutic modality.

The preferred treatment is usually arthrotomy, removal of loose

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bodies and synovectomy. Some authors perform the discectomy in the same surgical act to avoid recurrence (Holmlund et al., 2003; de Bont et al., 1988). Another less invasive alternative is arthroscopy (Shibuya et al., 2002). Consequently, a combined approach has been described to support the removal of chondromas in areas of difficult access. (Jang et al., 2021). However, none of the techniques has structural guidance to choose one therapeutic alternative over another.

The hypothesis of the study is that the multiple surgical options have an indication depending on the characteristics of the lesion. Therefore, these can be addressed in different ways, considering the requirements of each patient. The main study aim is to describe a surgical treatment algorithm for TMJ-SC based mainly on pre-surgical MRI evaluation to determine a rational surgical approach. As a secondary aim, it is intended to assist clinicians in developing a treatment strategy for this unusual pathology that could result in a predictable outcome.

2. Materials and methods

A literature review without language restriction of articles published between January 1990 and December 2022 was carried out following keywords: [“Temporomandibular synovial chondromatosis’’] AND [“TMJ arthroscopy’’] OR [“Arthroplasty” or “open surgery’’].

P: Adults diagnosed with synovial chondromatosis
I: Removal of synovial chondromatosis
C: Open surgery (OS), arthroscopic surgery (AS), or arthroscopy-assisted open arthrotomy (AA-OA)
O: Optimal or suboptimal removal.

Review Question: Are there indications based on MRI or CT characteristics to approach synovial chondromatosis using open surgery OS, arthroscopy AS, or arthroscopy-assisted open arthrotomy AA-OA.

2.1. Criteria for selecting studies in this systematic review

Inclusion criteria: Articles with subjects diagnosticated with TMJ-SC treated with arthrotomy or open surgery OS, AS, or arthroscopy-assisted open arthrotomy AA-OA. Case series were included if it had at least 5 patients over 18 years of age. Articles must describe the images evaluation, demographic information (age, gender, affected side, clinical characteristics), surgical approach and follow-up.

Exclusion criteria: Articles that included animal studies, connective tissue disease, non-surgical approach.

Variables.

Articles were read to complete demographic information, including their age (in years), gender (male or female) and affected side (right or left). The predictor variables included in the study were type of treatment (OS, AS, and/or AA-OA), MRI and CT assessment, preoperative decreased MMO, preoperative articular joint noise and preoperative pain (VAS). The outcome variables considered were recurrence measured by symptoms (MMO and VAS) and imaging findings. Other variables as type of surgery (OS, AS and AA-OA) were included.

2.2. Search methods for identification of studies

A literature search was performed in PubMed, Embase, Medline and LILACS, the key terms in natural language and controlled language were identified for the condition and interventions of interest. A generic search strategy composed of controlled vocabulary exploded as MeSH (Medical Subject Headings) without language limit, considering synonyms, abbreviations, acronyms, spelling, and plural variations was designed. Individual search strategies were developed for each source of information. This step was complemented by a search for additional publications using the snowball methodology.

2.3. Critical appraisal and assessment of risk of bias in included studies

All studies were evaluated independently and duplicated by two reviewers (JPL & MPO) to determine methodological quality using the Joanna Briggs Institute Verification List (JBI) for case series. The JBI checklists corresponded to ten questions requiring a yes, a no, or an unclear answer. All the studies that obtained more than seven "yes" were considered as an adequate methodological quality, those who presented at least five were considered as acceptable, and under five were considered low quality. Disagreements among the reviewers were subjected to the evaluation of a third reviewer (LVG).

2.4. Data collection process

The bibliographic references identified in the electronic searches were downloaded in the Rayyan® program. Duplicate publications were eliminated, and initial screening was carried out. First, the reviewers identified eligible articles by title. Afterward, each of the authors separately assessed the abstracts of these articles and selected potentially eligible studies. The reviewers subsequently independently verified the eligibility criteria (inclusion and exclusion) by reviewing each full-text publication.

2.5. Data extraction

The characteristics of the selected evidence were summarized according to what was reported in the original publications using a standardized data extraction format. The data collected included author, year, study design, population, type of surgery used (*OS,* AS*,* AA-OA), VAS, MIO, Imaging findings, and follow-up period.

2.6. Data synthesis

Due to the heterogeneity of study information (combining techniques and the way the primary outcomes were measured), statistical pooling was considered inappropriate, and the findings were summarized narratively. We produce the ’Summary of findings table’ for characterization of the information **-**Table 1.

2.7. Analysis plan

All the data was analyzed using Excel® program. Initially, a description of the data set was made by means of relative frequencies. In addition, a matrix of bivariate variables was generated with 3 input variables (joint noise, pain, and MIO) to relate it to a random output variable (type of treatment) and finally to a categorical variable (3 different variables without a numerical value). This was done in order to observe how the three input variables correlate with the output variable through different weight combinations (percentages).

3. Results

3.1. Description of the selection process

The study selection process and resume are shown in -Fig. 1. The total number of articles collected in the search carried out in the different databases was 272 articles, of which 90 remained after the duplicate removal. 58 of them were excluded based on the title. Then, 32 studies were evaluated for eligibility by the title and subsequently chosen to read the abstracts. A total of 20 studies were excluded based on the abstract and 12 were potentially pertinent to read in full text for detailed analysis. Finally, only 8 articles were selected based on the inclusion and exclusion criteria.

Table 1
Summary of literature review.

Author/year	Type of study	n:	Gender F	Gender M	Side L	Side R	Mean Age (y)	Swelling	Pain (# patients)	Mean preoperative MIO (mm)	Occlusal changes	Joint noise	Other complaints	MRI location involved	MRI	Disc pathology MRI	CT	Arthrscopy findings	Plain radiographs	Type of surgery	Treatment	Recurrence	Mean Follow-up
Ardekian et al. (2005)	Retrospective	11	8	3	5	6	54.5 (38–72)	8 (11)	10 (11)	Not mentioned	2 (11)	4(11)	Hearing loss 3 Renal calculi 2	A-L (1) L (4) M (2) (NE)2 A-M(1) L-S (1)	–	–	–	N/A	Calcifications (2)	OS (11)	S (4) S-D-T (5) S-D (1) S-D-T-C (1)	No	5,2 years
Fernández Sanromán et al., 2008	Retrospective	5	3	2	2	3	43 (34–56)	3 (5)	5 (5)	Not mentioned	4 (5)	3(5)	(−)	M − L-S (4) L-S (1)	Mass with low signal focci 5(5)		Calcifications (3) Glenoid fossa erosion (1) Condyle erosion (2)	Not mentioned	Condyle erosion (1)	AS (3) OS (2)	RLB (5) RBL-S (2)	No	4,3 years
Cai et al. (2012)	Retrospective	33	26	7	15	18	43.3 (21–62)	3(33)	20(33)	30.5	2(33)	18 (33)	Not mentioned	S 33(33)	Efussion 13 (33) Mass with low signal focci 29 (33) Glenid fossa and Condyle erosion 5(33)	Disc displacement 13(33) Disc perforations 1 (33)	Calcifications 1(33)	Loose bodies of 0.5–16 mm 31 (33) Intrasynovial islands of cartilage 6 (33) Synovial hyperplasia 12 (33)	Not mentioned	AS (33)	RLB (24) RLB-S (7) Disc repositioned (10)	No	38 months
Bai et al., 2017	Retrospective	36	25	11	22	14	48.1 (29–65)	Not mentioned	36(36)	27.4	Not mentioned	9(36)	mouth deviation 22(36) anterior open bite 1 (36)	S 36(36) S-M 14 (36)	Yes	Disc displacement 12(36)	Not mentioned	Loose bodies 36 (36)	Not mentioned	AA-OA (36)	RLB-S (36) Disc repositioned (12)	No	33.3 months
Brabyn et al. (2018)	Retrospective	6	5	1	6	0	42 (33–57)	2(6)	6(6)	32.3	Not mentioned	4(6)	Mouth desviation 3(3)		Efusion 4(6)	Disc perforations 1 (6) Disc displecement 3(6)	Loose bodies 6 (6)	Loose bodies of 0.5–3 mm 6(6) Synovitis (3) Chondromalacia	Normal 6(6)	AS (5) AA-OA (1)	RLB-S 6(6)	No	12 months
Lee et al.2019	Retrospective	16	14	2	9	7	32.6 (29–65)	8(16)	10(16)	30	Not mentioned	8(16)	Not mentioned	s 16 (16)	Loose bodies 15(16)	Not mentioned	Calcifications 2(6)	Loose bodies of 0.5–6.5 mm	Not mentioned	AS (16)	RLB-S 16(16)	No	3 years
Chen et al. (2012)	Retrospective	5	1	4	3	2	37 (29–50)	Not mentioned	4(5)	21.2	4(5)	2(5)	Mouth desviation 2(5) Posterior open bite 2 (5)		Calcification around condyle 1(5) Nodules 1(5) Condyle sclerosis 1(5)	Not mentioned	Bone erosion 1(5) Calcifications 1(5)	N/A	Not mentioned	OS (5)	RLB 1(5) C-CCG 1(5) D-C-CCG-T 3 (5)	No	18.4 months
Holmlund et al. (2003)	Retrospective	9	7	2	3	6	51 (24–81)	7(9)	9(9)	34.1				S 9(9) I 1 (9)	Efussion 9(9)		Not mentioned	Disc perforation 4(9) Loose bodies (9)	Not mentioned	OS (9) AS (1)	D(5) S(9)	No	5.4 years
Total		121	89	32	65	56	43,25	31	100		12	84											

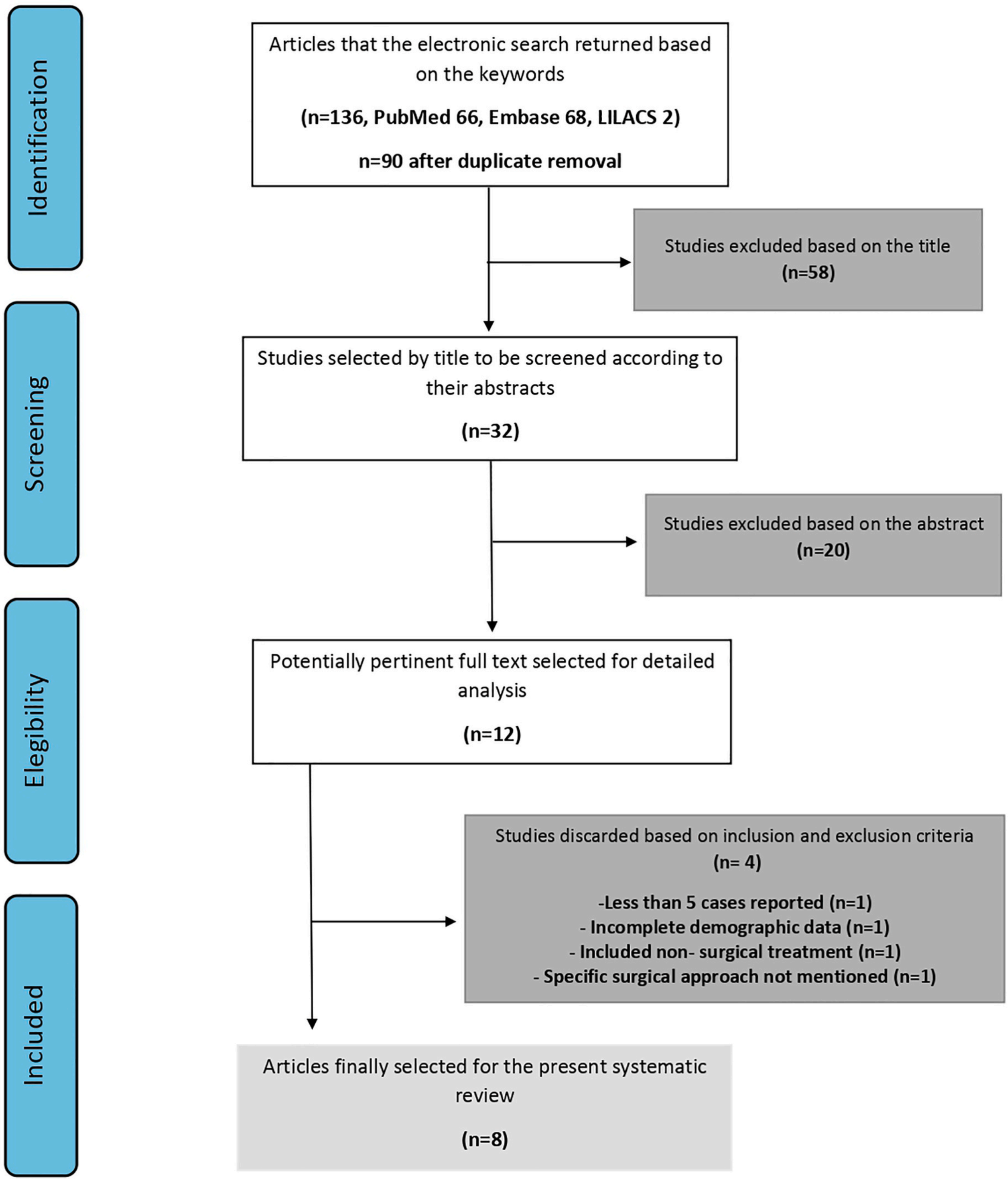

Fig. 1. Flowchart of the selection process.

Table 2
Variable analysis.

	NEUTRO = 25 mm	PAIN	ARTICULAR NOISE	OS	AS	AA-OA
Ardekian et al., (2005)	<25 mm	10(11) = 90%	4(11) = 36%	100%	0	0
Fernández Sanromán et al., 2008	<25 mm	5(5) = 100%	3(5) = 60%	0	60%	40%
Cai et al., (2012)	<25 mm	20(33) = 60%	18(33) = 54%	0	100%	0
Bai et al., 2017	NEUTRO	34(36) = 94%	9(36) = 25%	0	0	100%
Brabyn et al., (2018)	<25 mm	6(6) = 100%	4(6) = 60%	0	83%	17%
leeLee et al., 2019	<25 mm	9(16) = 56%	8(16) = 50%	0	100%	0%
Chen et al., (2012)	>25 mm	4(5) = 80%	2(5) = 40%	100	0%	0%
Holmlund et al., (2003)	<25 mm	9(9) = 100%	no reporta	100%	0%	0%

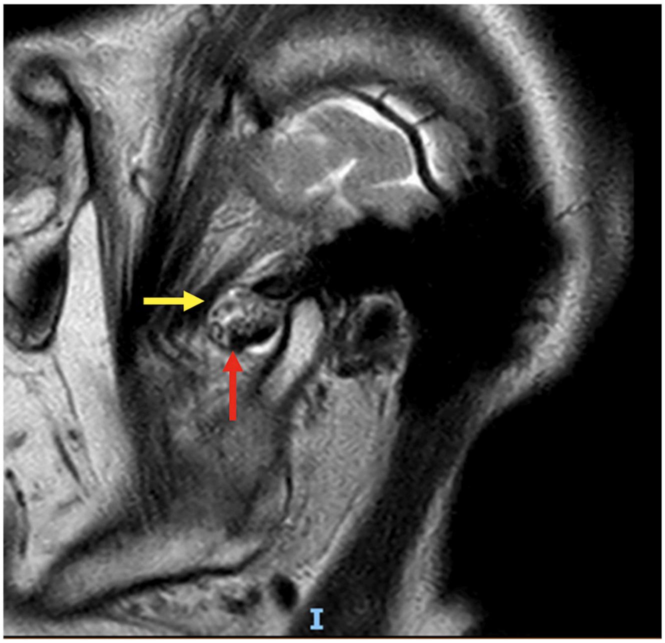

Fig. 2. MRI sagittal view where yellow arrow is showing a Mix Type. Red arrow is showing anterior disc displacement and important effusion.

3.2. Description of studies

A total of eight selected studies with a retrospective design were reviewed. 121 individuals were included, 89 percent of whom were women. All cases that followed the inclusion criteria were unilateral. The right side was the most affected (unilateral). The mean age was 43.2 year (21–81). Pain (n = 100), joint noises (n = 84), local inflammation (n = 31), or occlusal alterations (n = 13), were the most prevalent symptoms.

Imaging findings were loose bodies (n = 103), mass with low signal foci (n = 34), effusion (n = 26), and erosion of bone structures and calcifications were also observed. Disc disease, on the other hand, was visible, with disc displacement being the most common sign (n = 28).

In the cases of chondromatosis reviewed, the majority were managed by arthroscopy (47%), without considering the clinical or imaging findings. Open surgery seems to be the last option and could depend on some factors, such as the extent of the lesion or the surgeon's experience with other techniques. However, this indications are not specifically mentioned in the studies analyzed.

Removal of loose bodies (n = 96) was the most widely employed surgical treatment, either alone or in combination with synovectomy. A substantial number of patients underwent disc repositioning or discectomy (n = 49). Condylectomy and reconstructions using costochondral graft and temporalis flap were also performed. AS (n = 103), OS (n = 27) and AA-OA (n = 37) were the preferred methods for accomplishing this. There were no recurrences recorded.

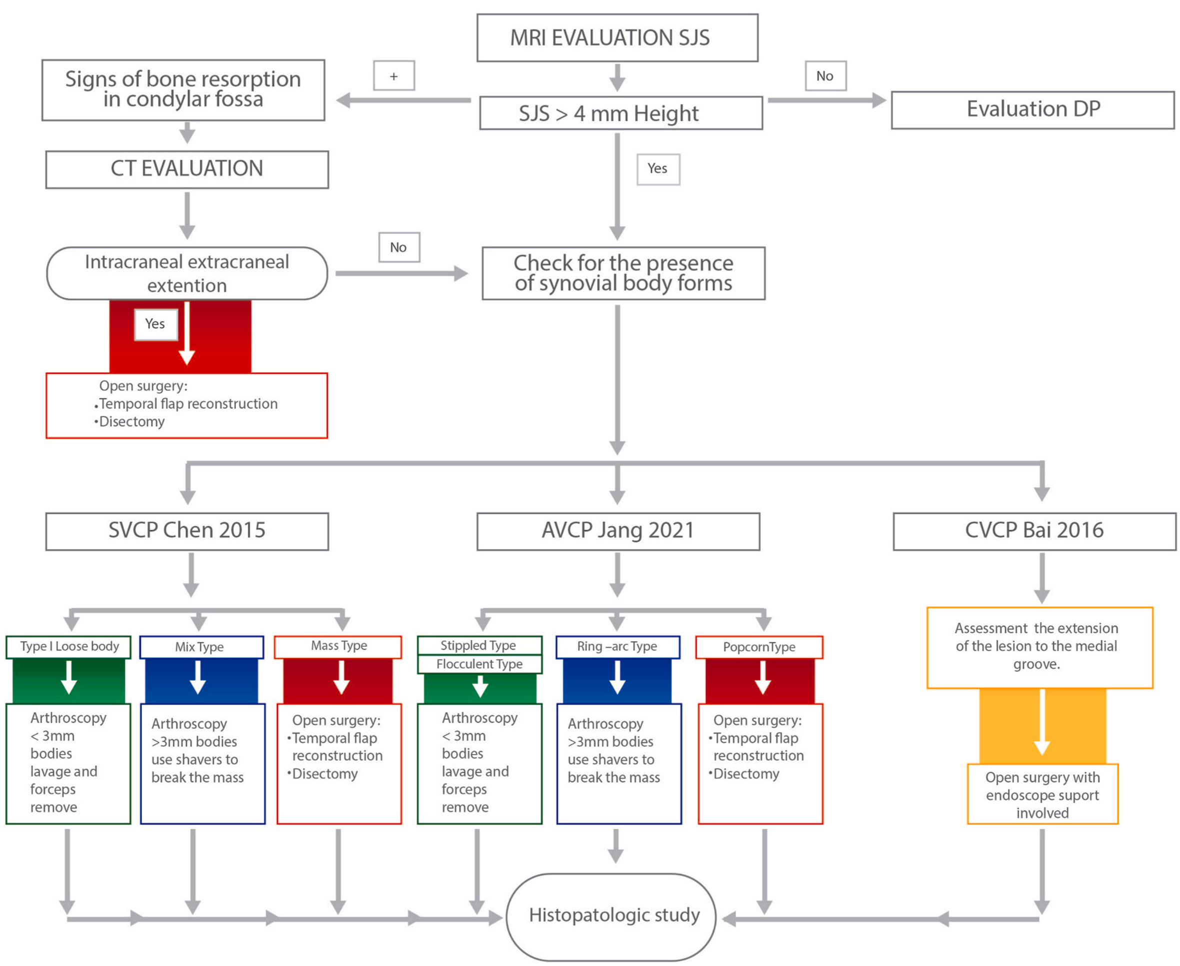

Fig. 3. The temporomandibular synovial chondromatosis algorithm for the superior joint space with color code. SJS: Superior Joint Space; DP: Disc Pathology; SVCP: Sagittal View Classification Pattern; AVCP: Axial View Classification Pattern; CVCP: Coronal View Classification Pattern.

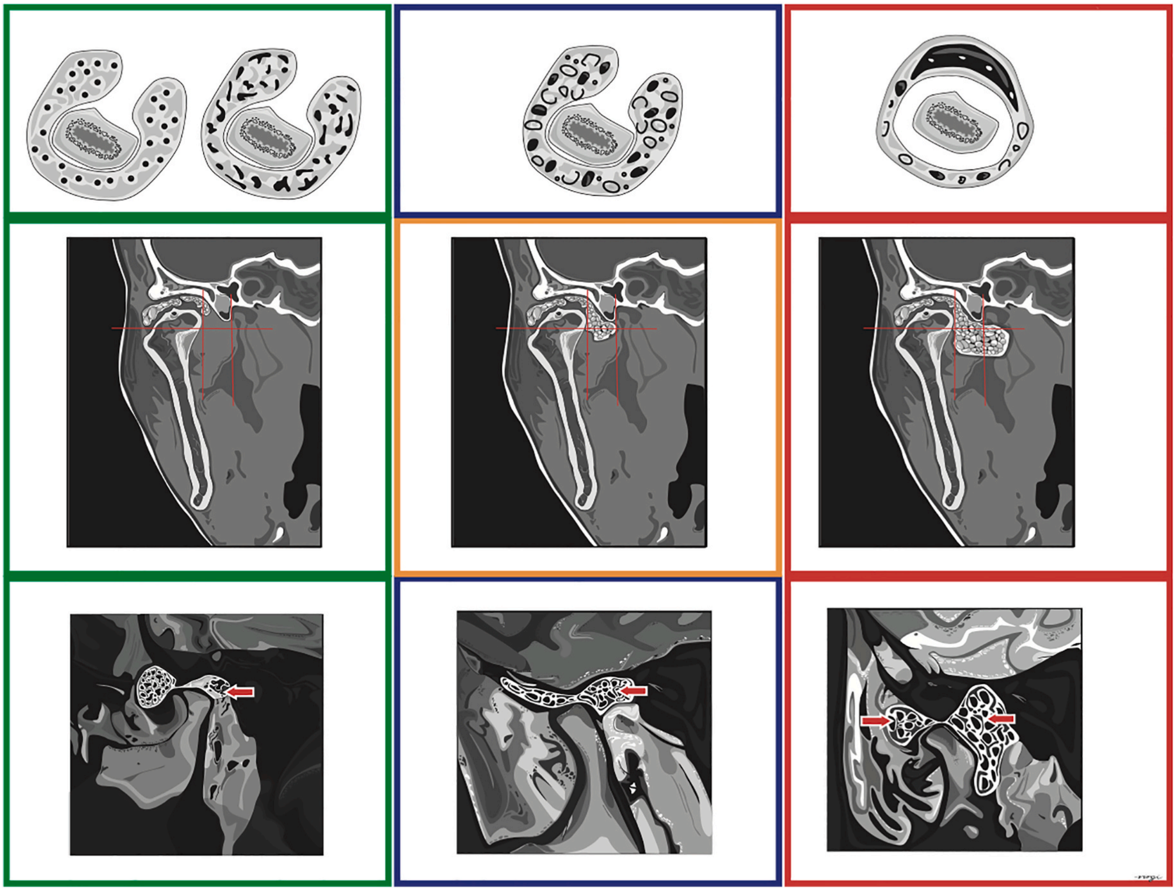

Fig. 4. Using color coding, an imaging guide for decision-making based on imaging classification for chondromatosis on MRI.

A relationship was found between open surgery and patients with preoperative MIO less than 25 mm, pain with a VAS between 6 and 8, and joint noise. On the contrary, when the patients did not have joint noise, a greater relationship with arthroscopy was found. Similarly, when they had at least 25 mm of MIO, pain with a VAS between 3 and 6, and minor noises, there is a stronger relationship with arthroscopy. Finally, it seems that all patients with an MIO greater than 25 mm present pain in 85% and joint noise in 52%. This could explain the greater tendency to perform arthroscopy over invasive open surgery - Table 2.

3.3. Risk of bias in included studies

The articles included in this review were classified as high, acceptable or low risk of bias following the Joanna Briggs Institute (JBI) checklist. According to the analysis that was carried out, one of the articles had a high risk of bias and most of them were classified as having an acceptable methodological quality. Additionally, one of them was classified as having an adequate methodological quality.

The item 'Were there clear criteria for inclusion in the case series?' was not clear in almost all the studies (Ardekian et al., 2005; Brabyn et al., 2018; Fernández Sanromán et al., 2008; Holmlund et al., 2003; Lee et al., 2019; Cai et al., 2012). Therefore, this item in those studies was classified as having a high risk of bias. In the same way, the domain 'Were valid methods used for identification of the condition for all participants included in the case series?'was often marked with a NO because in several studies chondromatosis was diagnosed with different diagnostic tools such as CT, MRI, simple X-rays and even arthrography. This indicates that there was no uniformity in terms of the use of the same diagnostic method for all participants (Ardekian et al., 2005; Chen et al., 2012; Holmlund et al., 2003; Cai et al., 2012). On the other hand, the other item that presented inconsistencies in the articles was the follow-up. In 2 of the articles included, the follow-up is presented very briefly in the text, being unclear to the reader (Chen et al., 2012; Lee et al., 2019).

4. Discussion

The present study intended to propose a treatment algorithm for TMJ-SC based on a literature review considering imaging findings. The hypothesis of the study was that the multiple surgical options have an indication depending on the characteristics of the lesion. Nevertheless, it was found that multiple authors based their surgical management in their own criteria mainly considering the extension of the lesion in the imaging findings.

The TMJ-SC is considered a tumor-like lesion; hence the imaging diagnosis is fundamental to reach a suitable surgical approach. Furthermore, a thorough presurgical evaluation is considered the most important fact to choose and set up an appropriate surgical planning to avoid the recurrence of this pathology and the reintervention. (Lucas et al., 1997; Von Lindern et al., 2002). There are many case series that describe the clinical experience with different treatments. (Liu et al., 2016; Sato et al., 2010). Despite the different approaches, there are still limitations in the understanding of the management of this condition and how a case could be fit in different surgical options.

Some noncalcified bodies may be difficult to see on a CT or plane X-ray in the early stages of pathology. Therefore, arthroscopy could be a supporting tool for diagnosis, and it could be combined with an open approach in the event of being necessary (Martín-Granizo et al., 2005). The MRI shows advantage over the CT and X-ray technique. It allows the

Fig. 5. The open approach combined with the endoscopic approach to reach the medial groove more effectively.

detection of noncalcified bodies in the early stages and can detect the synovium response of reaction (effusion). Also, it has shown to be superior with a rate of diagnosis of 93.75% compared to CT with a rate of 12.5% (Lee et al., 2019). Another study evaluated the precision of MRI in cases of SC evaluating 1415 joints. They related the findings with those obtained with OS or AS, concluding that the use of MRI is a recommended non-invasive tool for the diagnosis of TMJ-SC with an accuracy of 96.06% (Liu et al., 2019), confirming that it could be the gold standard for this purpose (Ida et al., 2008; Kim et al., 2002).

The arthrotomy is one of the surgical approaches to manage TMJ-SC combined with removal of free bodies and the involved synovial membrane (Koyama et al., 2001). In some cases, it should be considered to make a discectomy if both joint compartments are involved due to a disc perforation (Von Lindern et al., 2002). Otherwise, the non-malignant nature of the TMJ-SC allows consideration of many less invasive surgical methods in agreement with the pathology extension (Lieger et al., 2007).

Some authors prefer the OS as the first option. Ardekian, in a study suggests the use of concomitant treatments according to the patient's needs (craniotomy, discectomy, condylectomy or reconstruction). Also, in this study, the histopathological findings reported only stages I and II of the disease (Ardekian et al., 2005). This is why many authors recommend aggressive treatment in early stages of the disease. It is in these phases there is greater metaplastic activity, considered one of the risk factors related to recurrence. On the contrary, conservative treatment is defended in advanced stages where the disease is in a regression stage and has no detectable metaplastic activity (Aydin et al., 2002). Similarly, Miyamoto describes the management of two cases in the early phase of the disease. Successful results with arthroscopy-guided resection of metaplastic tissue with the naked eye. However, also presents a case with recurrence with OS. Recurrence in other articles was attributed to the incomplete resection of the affected synovium (Miyamoto et al., 2000). Hence after the complete retrieval of all nodules, a synovectomy with a diamond Burr is recommended (Martín-Granizo et al., 2005).

Another article published the use of OS, without recurrence and improvement in pain, mandibular function and swelling). Likewise, the use of arthroscopy is discussed, due to the diameter of the loose bodies greater than the diameter of the cannula (Holmlund et al., 2003). However, arthroscopy has proven to be effective. McCain, mentions the advantages of arthroscopy in this pathology. It defends the specificity of the technique in focusing on a specific area of the synovium, without the need for an approach as invasive as arthrotomy. Also, the ease of removing bodies that are in hard-to-reach locations, such as in the upper medial area of the capsule. On the other hand, he mentions the size of the free bodies due to the difficulty of adjusting them to the size of the cannulas (loose bodies >3 mm). Therefore, he recommended forceps, disc graspers and motorized shavers to achieve the proposed treatment (McCain and de la Rua, 1989). Another study included patients managed with AS and OS with radiofrequency for the treatment TMJ-SC. In turn, it establishes certain indications for management with AS or OS, mentioning that the latter is reserved only for the most aggressive cases where there are obvious masses in the TMJ area (Fernández-Sanromán et al., 2008). The medial space of the capsule proves to be an area of difficult access. For this reason, Bai suggests an adequate assessment through the coronal section of the extension and location of loose bodies in the medial groove of the superior joint space. In turn, it effectively proposes the AA to be able to access this area (Bai et al., 2017). In contrast, Cai et al., establish indications for the management of TMJ-SC through arthroscopy. They describe the handling of masses larger than 3 mm by using different tools or alternatives depending on the findings. An important contribution is to characterize the presence of synovial islands in early stages of the pathology. For the anterior recess, they recommend the use of the anterior lateral approach. In the posterior pouch and medial synovial drape can be treated through the transmeatal canal. On the other hand, it is mentioned that lesions in the superior compartment can be completely removed using a triple channel technique (Cai et al., 2012). In some cases, variations in arthroscopic techniques have been described. One of them is the possibility of performing intraoral endoscopic resections of benign pathologies of the glenoid fossa, which provides an alternative approach that does not include extraoral punctures and has shown good results. However, this technique, although it sounds promising, requires studies with a larger number of cases to establish a risk-benefit relationship with respect to classical extraoral techniques. (Valentini et al., 2015). One of the advantages of the intraoral access route in TMJ-SC is that it could facilitate handling on the medial aspect of the condyle.

4.1. *The temporomandibular synovial chondromatosis algorithm*

Following clinical evaluation, a symptomatic patient should have at least one image to assess for TMJ disorders. An MRI study should be the first option for patients with joint pathology considering that MRI has proven to be a very useful image in the diagnosis of this group of patients. There is a significant correlation between the MRI, clinical and arthroscopic findings. This suggests that magnetic resonance has a significant value. Therefore, an adequate presurgical imaging examination should be considered before submitting the patient to an invasive diagnostic procedure (González et al., 2021). Also, these is supported for a study that attempted to evaluate the diagnostic accuracy of magnetic resonance imaging MRI using the kappa coefficient and ROC curve (AUC-index). In this study, it was found that the incidence of synovial chondromatosis diagnosed on MRI was in accordance with the arthroscopic and open surgery (Liu et al., 2019).

The philosophy of the MRI TMJ-SC assessment should be directed toward checking the "effusion, low signal sphere form" and it focuses on the evaluation of the superior space, which is where the pathology

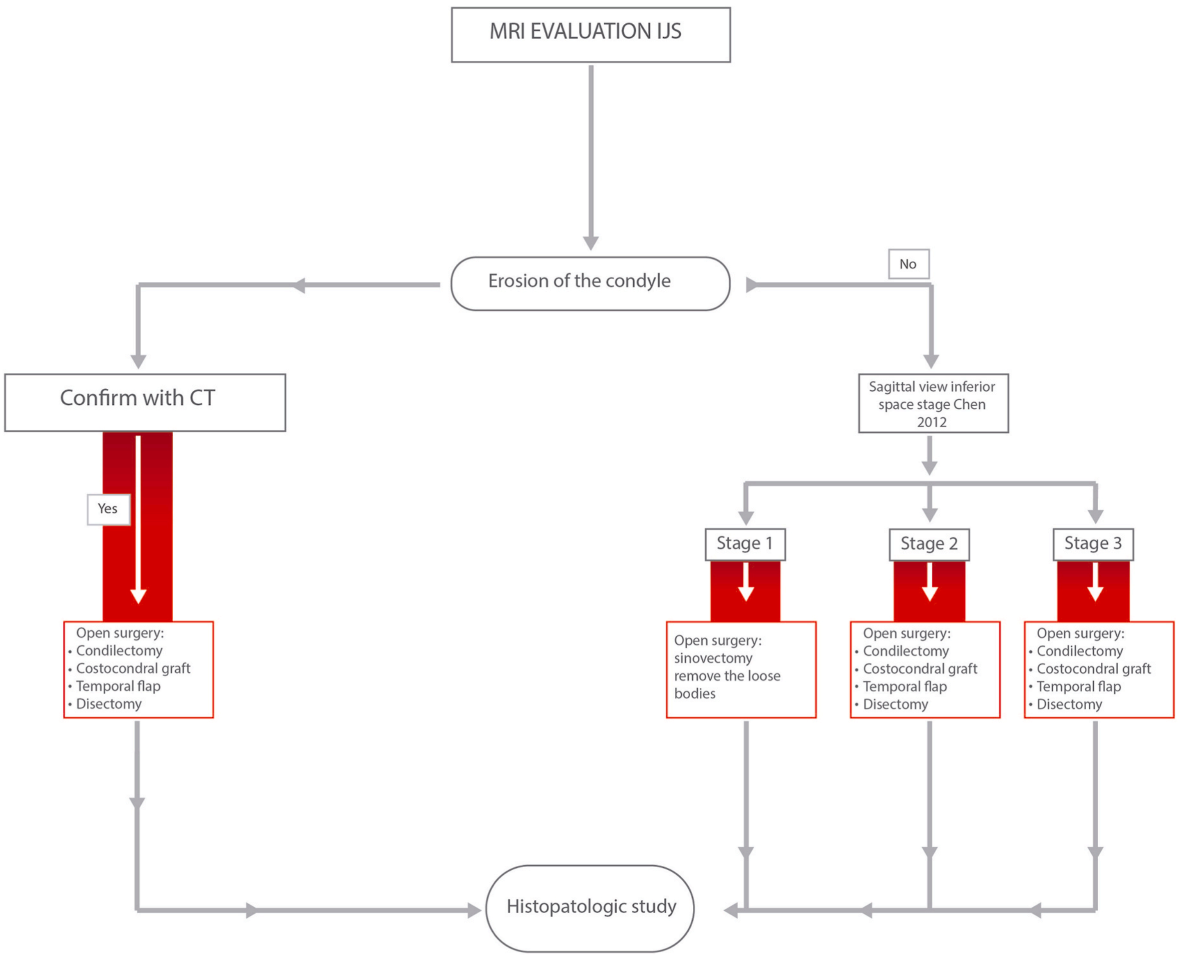

Fig. 6. The temporomandibular synovial chondromatosis algorithm for the inferior joint space with color code. IJS: Inferior Joint Space.

occurs the most. It starts by evaluating its height in the vertical dimension. If this is < 4 mm, another direction of diagnosis should be considered, checking if there are internal joint disorders. Otherwise (height >4 mm), it should be observed if there are synovial body forms in the different planes of the MRI (axial, sagittal and coronal). In the axial plane, four different types of calcifications can be found (stippled type, flocculent type, ring-arc type, and popcorn type) (Jang et al., 2021). In the sagittal plane, there are three stages of the lesion usually identified (loose body, homogeneous mass, and a mixture of both) (Chen et al., 2015) – Fig. 2. Likewise, in the coronal plane, the most important thing is to identify the extension of the lesion towards the medial groove, considering different anatomical references (Bai et al., 2017)- Fig. 3. The three views allow the surgeon to choose the approach for the treatment of the lesion, considering the most severe findings (red code), guided by the Imaging Guide for Surgical Approach in TMJ chondromatosis – Fig. 4.

For the loose body type, stippled type and flocculent type, AS (green code) could be the management with at least <3 mm free loose bodies with a proper operative technique. For ring-arc type calcifications and mass type >3 mm sizes, the AS could be supported by operative rotatory surgical tools (blue code).

In the coronal view, it is essential to check the involvement of the medial groove in the joint capsule. This is done by checking if the extension goes beyond the lower part of the medial crest of the condyle without reaching the condylar neck or the infratemporal fossa. These findings should be considered as an indication for AA-OA in order to more easily reach the medial groove (yellow code) –Fig. 5. For the popcorn type and mix type calcification, the OS is suitable to remove the entire calcifications combined with a synovectomy or discectomy if necessary (red code).

The assessment also considers checking certain anatomical osseous structures around, such as the articular eminence, the glenoid fossa, and the condyle. If there is any bone resorption, the surgeon should evaluate a CT scan to check the extracranial or intracranial dissemination. This aggressive pathology behavior implies an open approach with advanced reconstruction techniques (red code).

Although inferior joint space is unusually involved, the sagittal view of the MRI shows three possible model patterns. In the first model, it shows distinct nodules within an enormously expanded inferior joint compartment and an articular disc in the normal position with no calcifications in the CT. The second model shows some calcifications around the head of the condyle, hypertrophy of the condyle and a normal position of the disc in the MRI. The CT shows ossifications around the condyle and destruction of the cortical bone can already be perceived. The CT scans and MRI in the third model show sclerosis of the condyle with partial cupped reabsorption. The arthroscopic approach in the lower space is difficult due to the limited size of this compartment. Hence, the OS is always the best option to remove the loose body for the first stage (red code) –Fig. 6.

Otherwise, in the other two stages, it must be considered a high condylectomy or condylar shave depending on the compromise of the condyle. It may also be considered the use of costochondral grafts or TMJ replacement. Also, when the disc is involved, discectomy must be regarded as a simultaneous treatment with or without a temporal flap rotation to fill the space or a free fat graft obtained from the peri-umbilical area to avoid dead space within the joint (Wolford et al., 2008).

Currently there is no consensus on management depending on the extent, severity or location of the lesions. In the literature it was evidenced that the selection of the treatment modality is possibly dependent on the surgeon's experience with each technique instead of taking into account the individualization of the patient. Thus, with the proposed algorithm, certain indications were established. AS should be performed only on mass lesions that are confined to the superior joint space because it is difficult to remove the lesions in the inferior compartment by AS due to the narrow space. It is also indicated in mass lesions seen on MRI separate and mature without adhesions between fragments. However, OS is advocated in extra-articular extension of the pathology, such as the middle cranial fossa, articular eminence, lateral extension to the parotid gland, or medial extension to the infratemporal fossa. Finally, AA-OA is always an option when the pathology is extended towards the medial groove to facilitate the removal of the entire lesion.

Implications for clinical practice

Despite the variety and heterogeneity of the studies, the results are favorable, considering that recurrences have not been reported in any of the included studies. Therefore, the available alternatives are effective for the management of this pathology. However, it is difficult to make decisions in the treatment with the same results starting from the less invasive options This article can provide a guide to help clinicians make decisions in the presence of chondromatosis. However, this work does not claim to be absolutely right and is open to discussion in the academic environment.

Implications for investigation

It is mandatory to consider that this algorithm was carried out considering the case series available in the current literature and the experience of the authors. However, it is important to develop future studies that evaluate the results of this protocol proposal.

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Glossary

(S): Sinovectomy
(D): Discectomy
(T): Temporalis flap
(C): Craniotomy
(RLB): Removed loose bodies
(OS): ROpen surgery
(AS): RArthroscopic surgery
(AA-OA): RArthroscopy-assisted open arthrotomy; (C) Condylectomy
(CCG): RCostochondral graft
(A): RAnterior
(A-L): RAnterior-Lateral
(L): RLateral
(M): RMedial
(NE): RNo extension
(A-M): RAnterior-Medial
(L-S): Rlateral-superior
(SJS): RSuperior joint space
(DP): RDisc pathology
(SVCP): RSagittal view classification pattern
(AVCP): RAxial view classification pattern
(CVCP): RCoronal view classification pattern
(IJS): RInferior joint space