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ORIGINAL PAPER

An ultrasound working table as diagnostic tool of temporomandibular joint inflammation

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Abstract

Purpose To evaluate the use of ultrasound (US) in identifying the inflammatory or not inflammatory changes in different diseases that involve the temporomandibular joint (TMJ).

Methods 165 patients [50 Rheumatoid Arthritis (RA), 30 Psoriatic Arthritis (PsA), 15 Ankylosing Spondylitis (AS) and 70 Temporomandibular Disorders (TMD)] were studied by US with a linear probe 12–16 MHz (MyLABX8 eXP, ESAOTE S.p.A., Milan, Italy) placed along the axis of the mandibular branch. US results were compared with magnetic resonance imaging (MRI).

Results In TMJ, US identified joint effusion (JE), as well as disc displacement and modifications of the condylar profile. The specificity of US in comparison with MRI was 90.3% for JE, 75.2% for disc displacement, and 48.1% for condylar alterations. The sensitivity of US in comparison with MRI was 92.4% in the assessment of JE, 72% in the assessment of disc displacement, and 53% in the assessment of condylar alterations.

Conclusions US must be performed to define the inflammatory or not inflammatory changes of TMJ in different diseases adopting a specific working table. Moreover, the resulting disability may induce a significant loss of workdays for short and close periods with consequently high cost for the health care system.

Keywords Temporo-mandibular joint · Ultrasound examination · Inflammatory arthritis joint diseases · Temporomandibular disorders

Introduction

Ultrasound (US) is routinely used to detect inflammatory changes in many joints. Nevertheless, the heterogeneity of the published studies did not allow to identify the best diagnostic tool for assessing the inflammatory activity in temporomandibular joint (TMJ).

Magnetic Resonance Imaging (MRI) has been considered by clinicians as the gold standard method for the study of TMJ [1–5]. However, the method is expensive, is time consuming and may require the use of an intravenous contrast medium. Sometimes, and especially in children, sedation or general anesthesia may be necessary. On the other hand, US is an effective and low-cost diagnostic tool, widely available in several primary healthcare setting, used daily for assessing pathologic changes of musculoskeletal structures and could be considered effective and easy to use for the diagnosis of TMJ diseases in adults and in children as reported in previous studies [5–9].

In inflammatory joint diseases (IJD), like rheumatoid arthritis (RA), psoriatic arthritis (PsA) and ankylosing spondylitis (AS), the involvement of TMJ is characterised by a damage provoking a severe impairment of mouth opening and affecting patient's quality of life. Moreover, TMJ is a very important target of temporomandibular disorders (TMD) that involve both articular and muscular structures affecting approximately 5–15% of the population [10]. TMD are defined by Research Diagnostic Criteria (RDC) and include several clinical conditions ranging from TMJ limitation and pain induced by opening of the mouth to

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masticatory muscle pain [11–14]. Both conditions, IJD and TMD, are cause of chronic pain and even disability if untreated and have a negative impact on the psychological and social aspects of life. The impact on the population is difficult to quantify, but it is serious because functional problems, pain and complex psychopathological consequences, may be the causal or concausal factor of the disorder and may influence both the severity of symptoms and psychosocial aspects.

The aim of our study was to define the role of US in assessing TMJ inflammatory changes in different diseases adopting a specific working table.

Methods

A retrospective study was performed on 165 patients [80 females and 85 males (mean age 66.9 years)] with TMJ involvement and twenty healthy subjects matched for sex and age who had been examined in the Rheumatology Unit for outpatients of the University of Florence. 95 patients were affected by IJD (50 patients fulfilled ACR criteria for RA, 30 for PsA and 15 for AS) and 70 by TMD, defined by RDC. Differences among the five groups of patients matched for sex and age were not significant.

According to RDC a careful odontostomatologic examination was performed in all patients and in the healthy subjects. The healthy subjects in fact were selected if pain and crepitation on TMJ were absent and there was no previous history of rheumatic diseases or TMD. All the patients and healthy subjects were studied, by US and MRI, during mouth opening and closure [15–19].

Ultrasound

US was performed on both TMJ, in static and dynamic phases, with a linear probe 12–16 MHz (MyLABX8 eXP, ESAOTE S.p.A., Milan, Italy). All the assessments were performed by the same trained operator (DM). The TMJ is anatomically and biomechanically complex and can influence the growth of the mandible and other craniofacial structures (Fig. 1a–c) [20].

The TMJ consists of the condylar head and mandibular fossa with the tubercular joint of the temporal bone. The condylar head has an ellissoidal shape with the major axis oblique. The disc is placed between the mandibular condyle and the articular eminence of the temporal bone.

Examination of the TMJ by US may be not easy because of anatomical characteristics and because the ultrasound window may be small. It is important to know the ultrasound image we should expect when using the probe in a correct position.

TMJ was examined according to the following “Working table”.

Figure 2a shows the correct probe position to detect the condyle profile and the joint recess; Fig. 2b shows the corresponding condyle profile and the joint recess (see arrow) by US with longitudinal scan in a healthy subject.

Figure 3a shows the correct probe position to detect the condylar profile; Fig. 3b shows the corresponding condylar profile by US with coronal scan in a healthy subject.

Figure 4a shows the correct probe position at open mouth to detect the disc position; Fig. 4b shows the corresponding disc position by US with longitudinal scan in a healthy subject.

The probe was placed along the axis of the mandibular branch. In each joint the following TMJ features were evaluated: (1) joint space; (2) presence of joint effusion; the joint capsule appeared as a hyperechoic line running parallel to the surface of the condylar head and the thickness, measured as the distance bone-capsule, was two or more mm (> 95th percentile of controls) [7, 21, 22], (3) condylar profile; condylar profile was evident as a hyperechoic line, whose alterations suggested the presence of: (a) erosions, defined as a cortical “break” or defect with an irregular floor seen in the longitudinal or in the coronal plane [23, 24], (b) osteophytes, defined as marginal hypertrophic bone formation, (c) bone remodelling, defined as interruptions or depressions of the surface.

RDC were adopted to describe disc position [11–13].

Magnetic resonance imaging

TMJ investigation with MRI was carried out with either open or closed mouth with surface coil, 1.5 T (GE Signa Contour) and dedicated, circular polarized transmit and receive TMJ coil. MRI protocol included oblique sagittal and oblique coronal T1 TSE, T2 TSE and T2 GRE weighted images (time of repetition 340 ms; echo time 16 ms; flip angle = 30) with thin 3 mm slices thickness. MRI was angulated according to the horizontal angulation of the long axis of the condyle. Each subject received a wooden intermaxillary device to obtain the different and maximal opening mouth positions. Data were collected on a 512 × 512 matrix with a field of view of 15 mm. The following characteristics were evaluated: (1) morphological signals and alterations of the condyle; (2) morphological signals and alterations of the disc; (3) presence of joint effusion.

The articular disc was directly identified, in sagittal oblique images, as an area of hypointensity with a biconcave shape above the condylar structure and its position was categorized, according to literature data, as follows [5, 8, 25]:

- Superior (normal) disc position: posterior band of the articular disc located above the apex of the condylar head

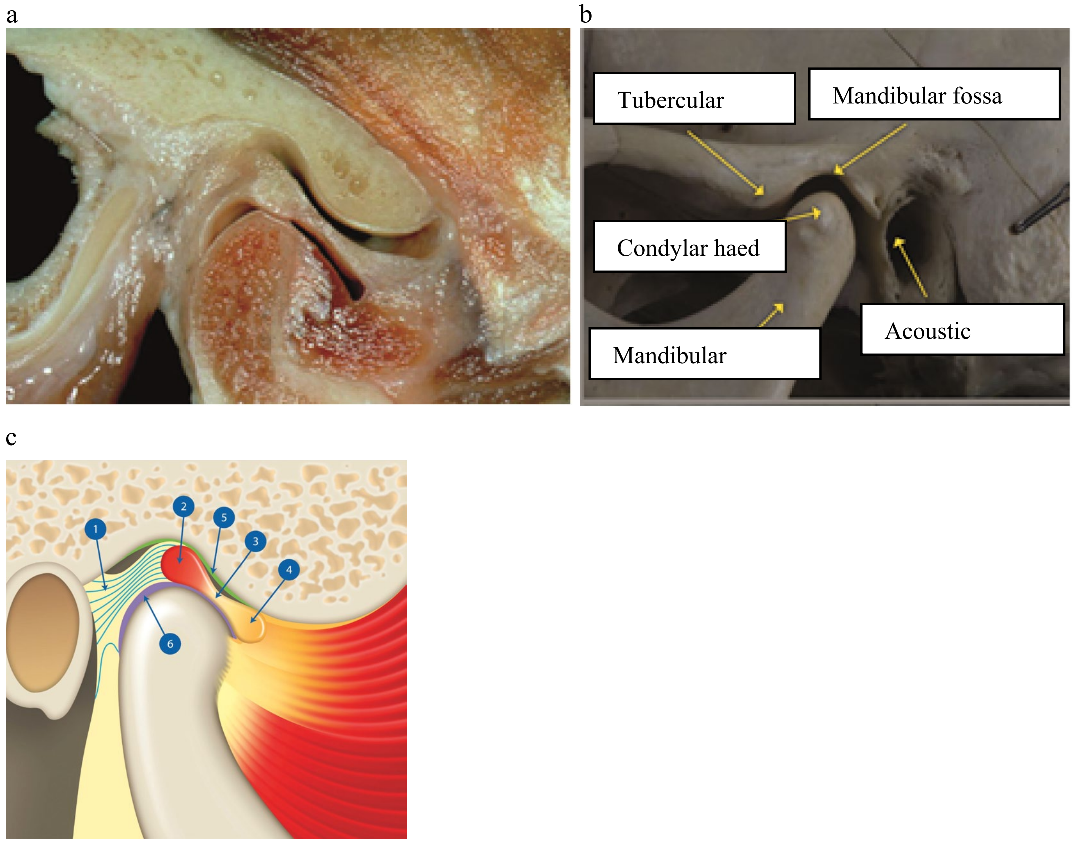

Fig. 1 **a** Anatomical section of a right temporomandibular joint, from L Vanini, C D'Arcangelo (2018) EFP—Estetica Funzione Postura, chapter 2, page 120, copyright—©Edra S.p.A. (with permission of Edra S.p.A.) [20]. **b** lateral view of the left temporomandibular joint from L Vanini, C D'Arcangelo (2018) EFP—Estetica Funzione Postura, chapter 2, page 120, copyright—©Edra S.p.A. (with permission of Edra S.p.A.) [20]; **c** schematic representation of the anatomical section of the right temporomandibular joint (1) bilaminar area, (2) posterior band, (3) intermediate band, (4) anterior band, (5) temporal articular surface, (6) condylar articular surface, from L Vanini, C D'Arcangelo (2018) EFP—Estetica Funzione Postura, chapter 2, page 120, copyright—©Edra S.p.A. (with permission of Edra S.p.A.) [20]

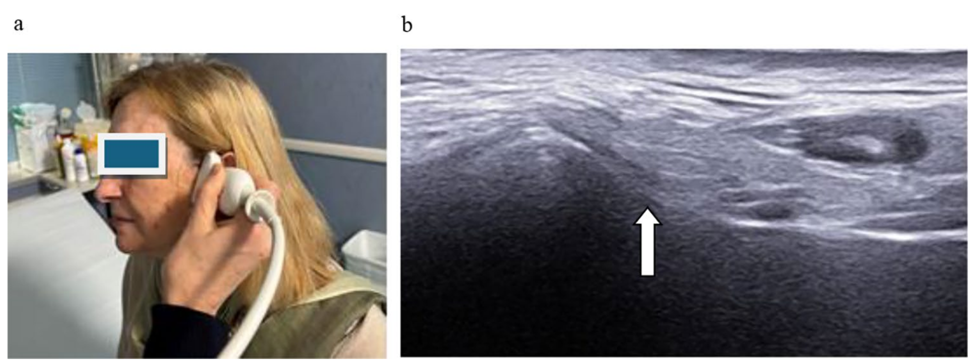

Fig. 2 **a** Correct probe position to detect the condyle profile and the joint recess; **b** corresponding condyle profile and the joint recess (see arrow) shown by US with longitudinal scan in a healthy subject

in both intercuspal and maximum opening mouth positions (Fig. 5 a and b).

- Disc displacement: posterior band of the disc located anterior to the condylar head at the closed mouth position; normal disc-condyle relationship might re-establish in maximal opening position (reducing disc displacement) or not (permanent disc displacement).

The presence of joint effusion was diagnosed when thin lines or an area of high signal intensity were depicted within the joint space.

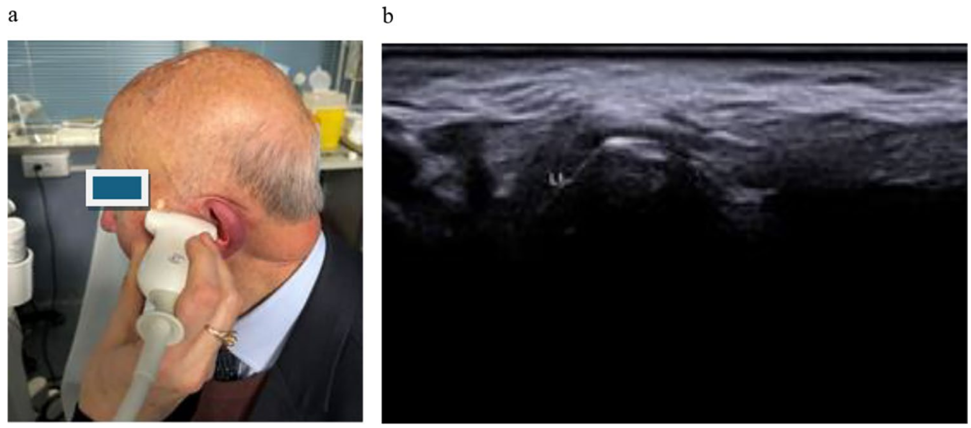

Fig. 3 **a** Correct probe position to detect the condylar profile; **b** corresponding condylar profile shown by US with coronal scan in a healthy subject

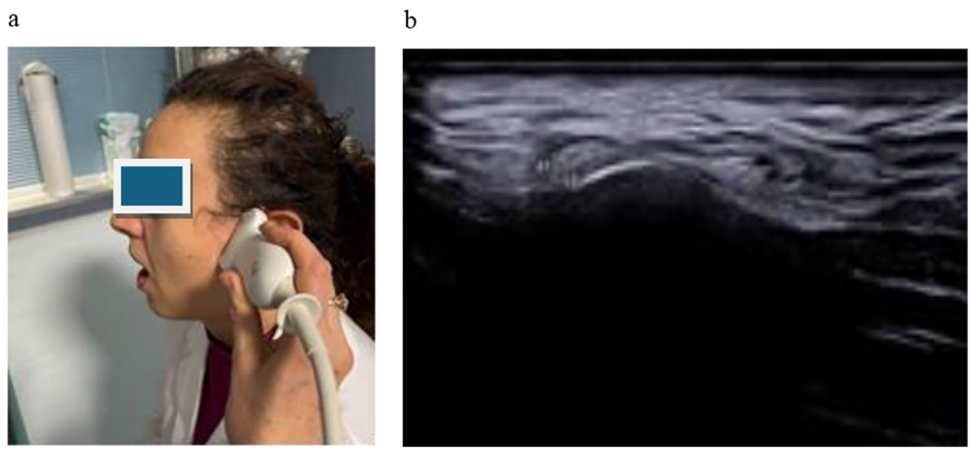

Fig. 4 **a** Correct probe position at open mouth to detect the disc position; **b** corresponding disc position shown by US with longitudinal scan in a healthy subject

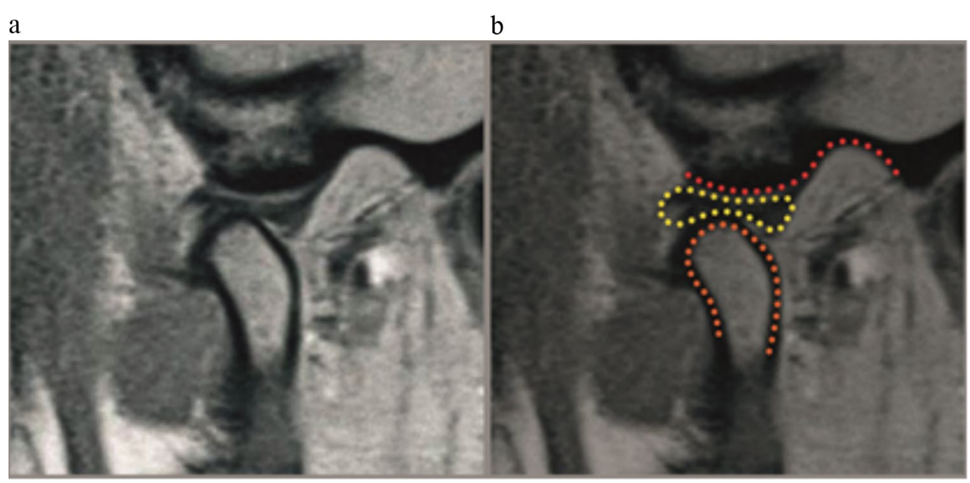

Fig. 5 **a** and **b** in physiological conditions, with the mouth open, the apex of the condyle (in orange) is positioned in correspondence with the apex of the articular eminence (in red) through the interposition of the thin intermediate zone of the articular meniscus (in yellow), from L Vanini, C D'Arcangelo (2018) EFP—Estetica Funzione Postura, chapter 2, page 143, copyright—©Edra S.p.A. (with permission of Edra S.p.A.) [20]

Changes of the condylar profile (erosions, osteophytes, remodelling) were diagnosed when alterations of the intensity of the cortical area and/or morphological alterations were evident.

All MRI were interpreted by the same trained radiologist.

Statistical analysis

Sensitivity, specificity, positive predictive value (PV+) and negative predictive value (PV−) of US were calculated (with 95% confidence limits) in comparison with MRI for the different structures examined. The intrareader (κ= 0.97) agreement was assessed. All statistical procedures were performed with the Statistical Package for the Social Sciences (SPSS for Windows).

Results

All RA patients reported bilateral TMJ pain and crepitation during mouth opening and closing, whereas all PsA patients had unilateral TMJ pain and only rarely crepitation.

No correlation with disease duration was found. In patients with TMD, pain and crepitation, during mouth opening and closing, were frequently unilateral (58.1%).

Ultrasound

In healthy subjects, the condyle presented a continuous and smooth profile of the bone. No asymmetry was evident between the mandibular branches and no significant differences between right and left side were observed.

No disc alteration was detected at closed mouth and maximum mouth opening positions. US clearly showed the disc in both positions. In healthy subjects, the mean thickness ± SD of joint capsule was not significantly different between right and left (1.42 ± 0.28 mm vs 1.28 ± 0.31 mm, respectively); the mean ± SD of both sides value was 1.35 ± 0.30 (range 0.8–1.9 mm, with a 95th percentile value of 1.6 mm).

In patients with RA, PsA and AS, US detected a decrease of the echo intensity of the periarticular tissue and an injured disc. At mouth opening the disc appeared always hypoechoic: this feature usually does not allow an accurate detection of disc profile due to oedema and swelling.

In 61 patients with IJD (44 RA, 15 PsA, 2 AS) (58%) and in 41 patients with TMD (58.5%), US showed joint effusion (Fig. 6a and b). Condylar alterations were observed in 62 patients with IJD (59.4%) (26 RA, 22 PsA, 14 AS) and in 43 patients with TMD (61.4%). Erosions were detected in 14 RA and in 9 PsA patients. Disc displacement (Fig. 6c) was evident in 51 patients with IJD (48.5%) (38 RA, 20 PsA, 3 AS) and in 28 TMD patients (40%) (Table 1).

MRI

In 6 healthy subjects, the condyle presented slight irregularities of the bone profile. Joint effusion was not present. No asymmetry was evident between the mandibular branches and no significant differences between right and left side were observed. Disc displacement and/or other alterations were not observed. Joint effusion was detected in 51/95 patients with IJD (54%) [11/30 PsA (Fig. 7a), 38/50 RA

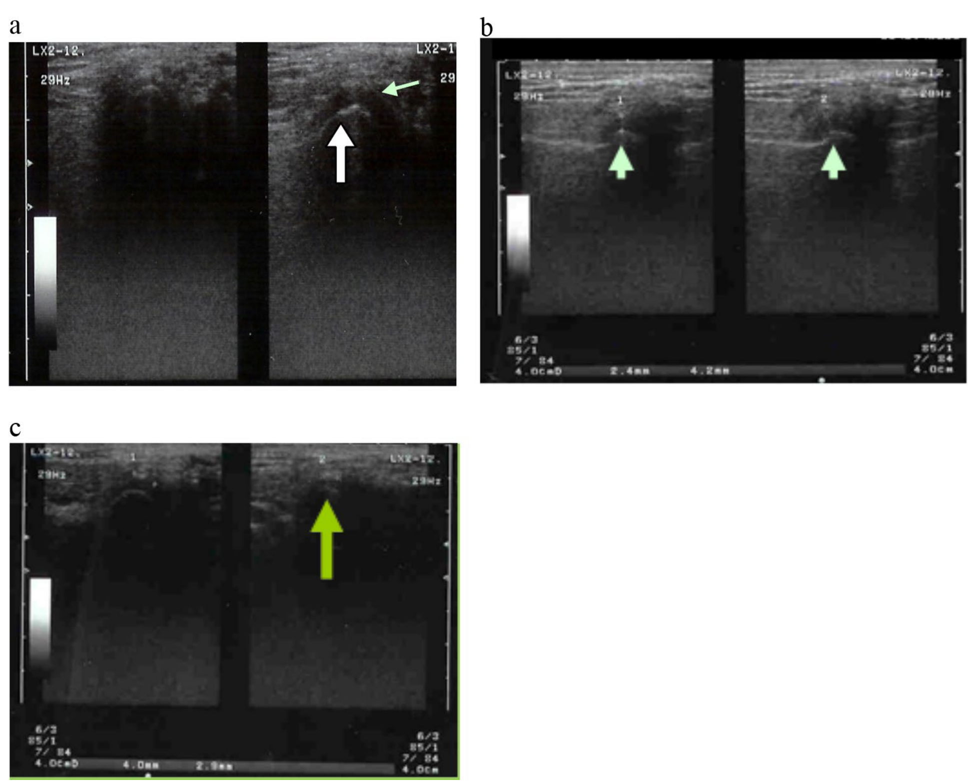

Fig. 6 **a** US: monolateral joint effusion and bone erosion (see arrow) in PsA. **b** US: bilateral joint effusion and alteration of the condylar profile in RA. **c** US: disc displacement in an anterior position (see arrows) relative to the superior part of the condyle in temporomandibular disorders (TMD)

Table 1 Alterations detected by US in comparison with MRI for each group (expressed in percentage values)

	IJD		TMD	
	MRI (%)	US (%)	MRI (%)	US (%)
Joint effusion	54.2	58	50	58.5
Condilar alteration	46.6	59.4	72.8	61.4
Disc displacement	50.4	48.5	31.4	40

(Fig. 7b), 2/15 AS] and in 35/70 patients (50%) with TMD (Fig. 7c). Condylar alterations were detected by MRI in 42 patients with IJD (44.2%) (20 RA, 13 PsA, 9 AS) and in 51 with TMD (72.8%). Erosions were present in 11 RA patients. MRI revealed also disc displacement in 46 patients with IJD (48.4%) (31 RA, 14 PsA, 1 AS), and in 22 patients with TMD (31.4%) (Table 1).

Ultrasound versus MRI

The concordance (Table 1) between US and MRI showed high specificity and sensitivity of US in comparison with MRI. For joint effusion, concordance was observed in 123 patients (70.2%): the sensitivity of US in comparison with MRI was 92.4% and the specificity was 90.3% (Predictive positive Value PV+ was 94.8% and Predictive Negative Value PV− was 86.1%). For disc displacement, a concordance with MRI was found in 111 patients (63.4%): the sensitivity of US in comparison with MRI was 72% and the specificity was 75.2% (PV+ 75.8%, PV− 71.3%). For condylar alterations a concordance was detected in 98 patients (56%): the sensitivity of US was 53% and the specificity was 48.1% (PV + 48.6%, PV− 52.5%).

Discussion

Our data show that US is a specific diagnostic tool for assessing TMJ modifications in IJD and TMD. Our results demonstrate that US may detect TMJ inflammatory modifications and condylar alterations more frequently than MRI.

In both, IJD and TMD, US showed the presence of joint effusion. In TMD joint effusion was found more frequently than expected. This finding in absence of pain is important for an early diagnosis in TMD. Indeed, it is important to note that pain in TMD is not usually related to the occurrence of joint effusion, but more often to disc displacement. Moreover, US showed the condylar alterations in IJD and TMD. In fact, US allows to identify the profile of the condyle and to observe a cortical "break", an erosion,

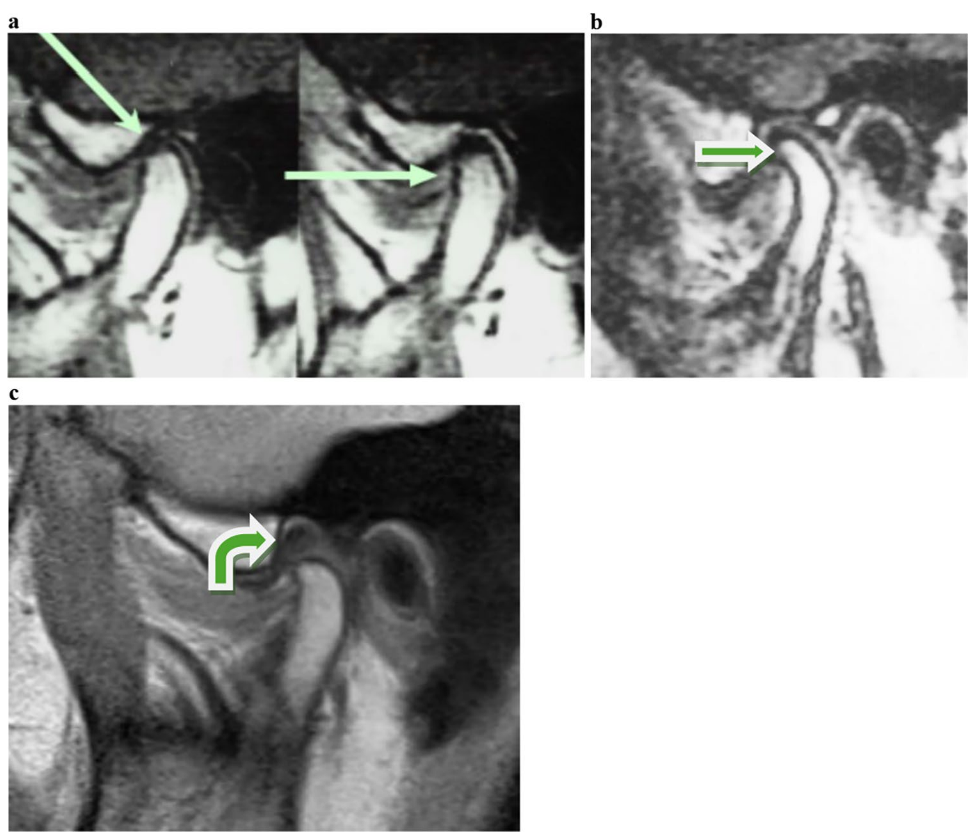

Fig. 7 **a** Sagittal oblique MRI shows joint effusion on the left (see arrow) and bone erosions on the right (see arrow) in PsA; **b** sagittal oblique MRI shows joint effusion on the left (see arrow) in RA; **c** sagittal oblique MRI shows disc position (see arrows) relative to the superior part of the condyle in temporomandibular disorders (TMD)

or flattening of the condylar head or osteophytes as small bone production [23, 24].

Our study showed that US may have a pivotal role in the evaluation of TMJ in early phase of all rheumatic diseases. Even in asymptomatic patients, we observed by US clear signs of joint inflammation in IJD and condylar alterations both in IJD and TMD. This evidence suggests that physicians should not neglect TMJ and should evaluate this joint systematically by US, both in inflammatory and non-inflammatory diseases. It is important to note that in children the inflammatory involvement of TMJ in Juvenile Idiopathic Arthritis (JIA) may have its onset in few weeks and may be not associated with pain or other clinical signs or symptoms. Moreover, the inflammatory involvement of TMJ in these young patients can lead to impaired facial growth, micrognathia, and mandibulofacial alterations such as a convex facial morphology [7]. As regards the different pathological changes detected by US, we observed that remodelling and osteophytes were evident in patients with TMD and AS while erosions and osteophytes were mainly observed in RA and in PsA patients.

In respect to previous studies, our findings show that US has a high specificity and sensitivity in evaluating condylar abnormalities and in assessing the dislocation of disc in both TMD and IJD [21, 25, 26]. Many authors suggested that US, in RA, was useful for the assessment of inflammatory and destructive changes of the bone [21, 24, 25]. In rheumatology, US has been mainly used in assessing patients with inflammatory joint diseases including the detection of bone erosions, synovitis, tendon disease, and enthesopathy [27]. Our results, suggest that US is an important diagnostic tool also for the study of TMJ and indicate that US is especially useful to detect joint effusion, changes of the profile of the condyle and disc position in dynamic phase. Some authors [3, 23] observed that MRI can identify both active arthritis changes as well as the consequences of arthritis with a moderate-to-good reliability, but the disruption of the cortical plate, in adult and paediatric arthritic patients, may be difficult to assess by MRI since there is no direct visualization of cortical structures without contrast enhancement. In view of the above, we should consider that clinical evaluation may be not reliable if not accompanied by US; MRI should be performed in patients who will undergo TMJ surgery.

The development of technology in US played an important role helping us in research activity to set up a valid and specific working table. In conclusion, our data corroborate the fact that US is a reliable procedure that might become a useful technique day-by-day for TMJ screening and follow-up. Early detection of TMJ effusion, starting in asymptomatic patients, should induce the physician to choose treatment to avoid the development of condylar lesions and loss of TMJ function, either in IJD and TMD. It must be considered also the impact on patient's quality of life and on social environment. In fact, the resulting disability may induce a significant loss of workdays for short and close periods and may have a high cost for the health care system.

Another not deferrable aspect is the association between TMD and negative emotions that have been demonstrated in both non-clinical and clinical subjects as well as the impact on individual quality of life and physical function is greatest when the clinical picture evolves toward chronicity. It is important to note that patients with chronic TMJ disorder tend to isolate themselves and show anxiety-depressive disorders [28].

Author contributions All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by [Daniela Melchiorre, Angela Bagni, Serena Guiducci], [Daniela Melchiorre, Diego Longo, Marco Maresca, Vanini Lorenzo, Alessio Frisone, Sara Torracchi e Pamela Bernardini] and [Daniela Melchiorre, Maria Angela Bagni]. The first draft of the manuscript was written by [Daniela Melchiorre] and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data availability We are available to provide data on request.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

Ethical approval This retrospective study was performed in line with the principles of the Declaration of Helsinki.

Consent to participate Informed consent was obtained from all individual participants included in the study.

Consent to publish The authors affirm that human research participants provided informed consent for publication of all the images.

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