Temporomandibular joint involvement in psoriatic arthritis: a prospective clinical and ultrasonographic study

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Abstract

Objective

To evaluate the prevalence of temporomandibular disorders (TMD) in a monocentric cohort of patients affected by psoriatic arthritis (PsA), and to investigate the accuracy of temporomandibular joint (TMJ) ultrasound (US) compared with clinical evaluation and clinimetric composite index in assessing TMJ involvement.

Methods

We conducted a prospective cohort study of patients diagnosed with PsA who underwent at least one TMJ US examination and maxillofacial surgeon's evaluation between 2018 and 2021. The rheumatology physician's interpretation of each TMJ US exam (presence/absence of TMD) was compared with psoriatic arthritis disease activity indexes and maxillofacial surgeon's clinical judgement (presence/absence of TMD signs and/or symptoms).

Results

142 psoriatic arthritis patients were included. 111 patients were totally asymptomatic for TMD, but 58.5% of them already showed TMJ US changes; moreover, 103 patients passed the maxillofacial surgeon's examination in the absence of any relevant findings but again, of these, 55.3% already presented US signs of TMD. Univariate analysis of subgroups with and without TMJ synovitis and with and without active power Doppler signal showed a significant prevalence of peripheral enthesitic involvement in patients affected by TMD (95.7% vs. 4.3%, p=0.001; and 72.2% vs. 27.3%, p=0.007, respectively). Multivariate regression analysis confirmed the results (p=0.01 and p=0.013, respectively).

Conclusion

Peripheral enthesitic involvement may represent a potential risk factor for the development of TMJ synovitis in PsA patients. Since TMD often develops asymptomatically, TMJ US may detect early signs of TMD, ensuring precocious and adequate management.

Key words

temporomandibular joint, temporomandibular disorders, ultrasound, psoriatic arthritis, enthesitis.

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Introduction

Psoriatic arthritis (PsA) is a heterogeneous chronic inflammatory condition affecting 0.3–1% of the population and up to 30% of people with psoriasis (1). Musculoskeletal manifestations of PsA include peripheral arthritis, enthesitis, dactylitis and axial involvement, often variously combined with each other (1). PsA is also associated with extra-articular manifestations and several comorbidities, including uveitis, inflammatory bowel disease (IBD), obesity, metabolic disease, depression and anxiety (2, 3).

TMJ disorders (TMDs) are the second most common musculoskeletal condition worldwide following chronic low back pain. TMDs affect approximately 5–12% of the general population during lifetime, causing chronic pain and even disability if left untreated (4).

Although the most common causes of TMDs are physical (orofacial issues, malocclusion, disc displacement) and psychosocial factors (such as bruxism) (4, 5), inflammatory joint pathology should not be neglected in the comprehensive evaluation of TMD (6-8).

The classification of TMDs includes in fact three subcategories: derangements of the condyle-disc complex, structural incompatibility of the articular surfaces and inflammatory disorders (5).

Therefore, patients with a known diagnosis of inflammatory chronic rheumatic diseases such as rheumatoid arthritis (RA), PsA and ankylosing spondylitis (AS) (1) should be regularly screened for TMD involvement.

The extent of clinical TMJ involvement in PsA is not fully clarified, as there are very few data in the literature about the prevalence of TMDs in psoriasis (PsO) and PsA. It is likely to be more common than generally described, as outlined in studies documenting TMDs through imaging techniques, compared to patients' self-reported signs and/or symptoms (7-20).

However, TMJ is one of the most difficult joints to assess clinically, as swelling is relatively infrequent; moreover, in early stages of disease, patients may be completely asymptomatic (9, 10). Therefore, while the presence of some specific abnormalities on TMJ examination is strongly suggestive of TMJ involvement, their absence does not rule it out (12).

Currently, magnetic resonance imaging (MRI) is considered the *gold standard* imaging technique for the evaluation of inflammatory and degenerative processes in TMJ pathology, as it can identify both active arthritic changes and arthritic sequelae, exhibiting a high reliability (12). Nonetheless, thanks to modern high-frequency probes, osteoarticular ultrasonography (US) proved highly sensitive in highlighting the presence of inflammatory and degenerative joint changes, even more than clinical examination itself. TMJ US has therefore recently emerged as a useful tool in the first-step evaluation of TMDs due to several advantages over MRI: low cost, wide availability, and rapid evaluation, all favourable elements, avoiding claustrophobic concerns, particularly in paediatric population (9). Further, contrast enhancement is not routinely performed in MRI studies, while power Doppler is easily detectable in every ultrasound examination (6). US diagnosis of effusion has been favourably compared to MRI technique, especially when the capsular width is above 1.950 mm in the adult population (7). Few studies showed no considerable differences between synovial inflammation obtained using power Doppler US or determined through MRI images (8, 9). However, it is unclear whether US can identify active inflammation and arthritic sequelae as accurately as contrast enhancement MRI (6).

The main aims of our work were to assess the prevalence of clinical symptoms and signs of TMJ involvement in a prospective consecutive series of PsA patients; to investigate the role of TMJ US in the early detection of TMJ alterations, particularly in clinically asymptomatic or oligosymptomatic patients; further, we explored correlation between PsA clinimetric indexes, TMJ US and TMJ clinical findings.

Methods

Study design and population

All PsA patients consecutively referred to our Spondyloarthritis Outpatient Clinic between 2018 and 2021 were

enrolled. Inclusion criteria were the satisfaction of the CASPAR classification criteria for PsA (10) and age over 18 years.

Exclusion criteria were previous acute traumatic injury or surgery history, history of major dental changes (*e.g.* known malocclusion issues), neurological disorders, history of non-rheumatologic TMJ issues (*e.g.* severe craniofacial abnormalities, traumatic TMDs) and patients with fibromyalgia (11).

As a control group, forty healthy volunteers, without known inflammatory and/or degenerative rheumatic diseases and without signs and/or symptoms of TMJ involvement either at the time of enrolment or in their personal medical history were recruited. The two groups had homogeneous characteristics with regard to gender and mean age.

Both patients and controls were evaluated separately by two rheumatologists experienced in joint US, who performed alternatively clinical examination of PsA patients or US evaluation of TMJ (to guarantee blinding in order to limit possible bias if one rheumatologist alone would have performed both clinical and US assessment), and by the maxillofacial surgeon, who performed the clinical examination of TMJ (the study design is shown in Supplementary Fig. S1). All data were collected in accordance with protocols reported in previous studies (12-16).

PsA disease duration, current and previous drug therapies, comorbidities, number of painful and swollen joints involved, C-reactive protein (CRP) values and main clinimetric indexes (13-18), were recorded. In addition, PsA was classified according to the subset of involvement (peripheral, axial, enthesitic, dactylitic). Axial involvement was defined by the presence of inflammatory low back pain and abnormal lumbar spine and/or sacroiliac joints radiographic and/or MRI features.

In accordance with the declaration of Helsinki, all patients gave informed consent before inclusion in the cohort. This study was approved by the local Institutional Ethics Review Board.

Maxillofacial examination

Clinical evaluation of TMJ involvement included: the presence of spontaneous and/or evoked pain on palpation of the TMJ, quantified by visual analogue scale (VAS) from 0 to 10); functional limitation, assessed by measuring maximum spontaneous and forced mouth opening; the presence of jaw noises (including clicking, crunching or clunking); and the presence of temporalis and/or masseter palpation-induced pain.

TMJ PD-US assessment

TMJ PD-US examination was performed bilaterally with the patient in the supine position and the probe positioned parallel to the mandibular condyle and perpendicular to the zygomatic arch (configuring longitudinal scan, most commonly employed in clinical practice) (Suppl. Fig. S2). A 12–18 MHz linear probe (Toshiba Aplio XG ultrasound scanner) was used. Doppler frequency was calibrated at 12.2 kHz. Pulse repetition frequency (PRF) was 2.1. PD signal gain was calibrated for each individual image immediately below the appearance of the first artifact (average of colour gain: 35 kHz).

The following parameters were evaluated in each TMJ (right and left):

- Joint space: joint effusion, synovial hyperplasia, power Doppler (PD) signal
- Articular cartilage: reduced thickness, echostructural inhomogeneity
- Bone profile: bone cortical irregularities, erosions, osteophytes
- Articular disc: echogenicity and thickness, disc dislocations, calcifications.

A semiquantitative score according to Naredo (19) was used to quantify the PD signal (grade 0–3; 0 = normal, absence of intra-articular flow signals; 1 = mild, evidence of a single flow signal; 2 = moderate, confluent vessels; 3 = marked, evidence of multiple flow signals in more than half of the intra-articular surface). A semiquantitative score (grade: 0–3; 0 = normal; 1 = mild; 2 = moderate; 3 = marked) was also used to quantify joint effusion and synovial hyperplasia. TMJ-US was performed by two experienced sonographers; the Bland-Altman method was used to assess the degree of agreement among the two examiners (Suppl. Fig. S3).

Statistical analysis

Categorical variables were expressed as frequencies and percentages, while all Gaussian-distributed continuous variables were presented in terms of mean ± standard deviation (SD). Student's t-test for unpaired data was used for comparison of means for normal-distribution variables; dichotomous variables were paired using the chi-square test in order to compare the different characteristics between the group with US-documented synovitis and the synovitis-free group, and between the group with active PD synovitis and the group with inactive synovitis.

Therefore, stepwise multivariate logistic regression analysis was developed using the variables identified by univariate analysis, with US-documented synovitis and PD-positive US synovitis entered as dependent variables, to explore correlations between US, clinical and clinimetric parameters of PsA.

An alpha significance level of 5% was considered for all statistical analyses.

Table I. Main TMJ ultrasonographic changes in PsA patients and control group.

Ultrasonographic changes	PsA group (n=142)	Control group (n=40)	*p*-value
Synovitis, n (%)	95 (66.9%)	2 (5%)	**<0.001**
Erosions, n (%)	26 (18.3%)	2 (5%)	**0.046**
PD signal, n (%)	44 (30.9%)	0 (0%)	**<0.001**
Reduced cartilage thickness, n (%)	20 (14.08%)	8 (20%)	0.456
Condylar surface irregularities, n (%)	16 (11.27%)	0 (0%)	**0.025**
Condylar osteophytes, n (%)	26 (18.3%)	0 (0%)	**0.001**
Calcifications, n (%)	14 (9.86%)	0 (0%)	**0.04**

PD: power Doppler; PsA: psoriatic arthritis

Results

Our study included 142 PsA patients, of whom 95 (66.9%) presented US-TMJ synovitis; in this latter group, 44 patients (46.3%) were documented as active power Doppler synovitis.

Forty asymptomatic healthy subjects were enrolled in the control group. US examination showed TMJ changes in 12 patients (30%), in terms of synovitis (n=2; 5%), erosions (n=2; 5%), reduced cartilage thickness (n=8; 20%).

Table I shows the main TMJ ultrasonographic changes in PsA patients and healthy group.

Table II shows the main descriptive demographic, clinical, laboratory and drug history data of the general study population (with PsA) and the subgroup of patients with PsA who presented with US-documented synovitis.

Because of missing data, general study population measurements of Bath Ankylosing Spondylitis Disease Activity Index (BASDAI) were evaluated in 140/142 patients, Ankylosing Spondylitis Disease Activity Score (ASDAS) in 139/142 patients, Psoriasis Area and Surface Index (PASI) and psoriatic subset data in 139/142 patients.

Among 142 PsA patients, 31 (21.8%) complained of subjective symptoms of TMJ involvement (pain or jaw noises), and 39 (27.5%) presented at least one clinical objective sign of TMDs at Maxillofacial evaluation; of these 97% also showed US TMDs findings.

111/142 PsA patients did not account for any TMJ symptom, but 65/142 (58.5%) already exhibited TMJ US changes. Furthermore, 103 patients passed the Maxillofacial surgeon's evaluation without any major finding. However, again, 57 (55.3%) showed US TMD signs (Suppl. Fig. S4).

Table III presents the univariate comparison analysis between the group with US-documented TMJ synovitis (n=95) and the synovitis-free group (n=47). Table IV presents the univariate comparison analysis between the group with active PD TMJ synovitis (n=44), compared with patients with TMJ synovitis without PD signal (n=51).

Univariate analysis of subgroups with and without US-TMJ synovitis showed a prevalence of peripheral enthesitic involvement in the group with TMJ synovitis (95.7% *vs*. 4.3%; p=0.001). Concerning clinimetric setting, higher score of Bath Ankylosing Spondylitis Functional Index (BASFI) (2.23±2 *vs*. 1.63±1.84; p=0.048) and high disease

Table II. PsA population (all patients) and PsA population with TMJ US synovitis.

Demographic information	PsA (all patients) (n=142)	PsA patients with US documented synovitis (n=95)
Age (years, mean ± SD)	57.6 ± 10.5	58 ± 9.4
F, n (%)	68 (47.9%)	48 (50.5%)
BMI, mean ± SD	25.6 ± 3.6	25.3 ± 3.1
Rheumatological disease features		
Disease duration (years, mean ± SD)	8.5 ± 7.3	7.5 ± 6
PsA subset, n (%)		
Peripheral arthritis	47 (33.1%)	35 (36.8%)
Enthesitic	23 (16.2%)	23 (24.2%)
Dactylitic	1 (0.7%)	1 (1.1%)
Axial	5 (3.5%)	4 (4.2%)
Peripheral (any subset) + axial	4 (2.8%)	3 (3.2%)
Psoriasis, n (%)	63 (44.4%)	45 (47.4%)
Therapies, n (%)		
None	8 (5.6%)	2 (2.1%)
Only NSAID or steroids	10 (7%)	7 (7.4%)
Only cDMARD	99 (69.7%)	69 (72.6%)
Only bDMARD	17 (12%)	13 (13.7%)
cDMARD + bDMARD	8 (5.6%)	4 (4.2%)
Comorbidities, n (%)		
Cardiovascular	72 (50.7%)	50 (52.6%)
Hypertension	49 (34.5%)	38 (40%)
Type 2 diabetes	11 (7.7%)	6 (6.3%)
Dyslipidaemia	31 (21.8%)	18 (18.9%)
Hyperuricaemia	5 (3.5%)	3 (3.2%)
Metabolic syndrome	1 (0.7%)	0 (0%)
TMJ symptoms, n (%)		
Subjective reported symptoms	31 (21.8%)	27 (28.4%)
Objective signs (*e.g*. pain. jaw sounds)	39 (27.5%)	35 (36.8%)
Clinimetric indexes		
BASFI, mean ± SD	2.04 ± 1.96	2.04 ± 1.96
BASDAI, mean ± SD	3.76 ± 2.31	4.03 ± 2.26
BASDAI <2.8, n (%)	61 (43%)	39 (41.1%)
BASDAI 2.8 <4, n (%)	15 (10.6%)	7 (7.4%)
BASDAI ≥4, n (%)	64 (45.1%)	48 (50.5%)
ASDAS-PCR, mean ± SD	2.02 ± 1.07	2.07 ± 1.03
ASDAS <1.3, n (%)	39 (27.5%)	25 (26.3%)
ASDAS 1.3 <2.1, n (%)	30 (21.1%)	17 (17.9%)
ASDAS 2.1 <3.5, n (%)	56 (39.4%)	43 (45.3%)
ASDAS ≥3.5, n (%)	14 (9.9%)	8 (8.4%)
DAPSA, mean ± SD	7.85 ± 7.60	8.18 ± 7.87
DAPSA ≤4, n (%)	55 (38.7%)	32 (33.7%)
DAPSA 5–14, n (%)	59 (41.5%)	44 (46.3%)
DAPSA 15–28, n (%)	24 (16.9%)	15 (15.8%)
DAPSA >28, n (%)	4 (2.8%)	4 (4.2%)
PASI, mean ± SD	2.73 ± 4.23	2.93 ± 4.34
PASI <10, n (%)	130 (97.9%)	88 (92.6%)
PASI 10–15, n (%)	4 (2.8%)	0 (0%)
PASI >15, n (%)	5 (3.5%)	5 (5.3%)
PCR (mg/L), mean ± SD	4.43 ± 5.73	4.59 ± 6.38
SJC, mean ± SD	0.5 ± 0.99	0.54 ± 0.89
TJC, mean ± SD	1.06 ± 2.32	1.19 ± 2.48
PtGA (0-10), mean ± SD	3.01 ± 2.61	3.12 ± 2.61
PtPain (0-10), mean ± DS	2.96 ± 2.48	3.01 ± 2.44

Demographic, clinical, laboratory and drug history data of the general study population and the subgroup of patients who presented with US-documented TMJ synovitis.

ASDAS: Ankylosing Spondylitis Disease Activity Score; BASDAI: Bath Ankylosing Spondylitis Disease Activity Index; BASFI: Bath Ankylosing Spondylitis Functional Index; BMI: Body Mass Index; CRP: C-reactive protein; DAPSA: Disease Activity Index for PSoriatic Arthritis; bDMARDs: biological disease-modifying anti-rheumatic drugs; cDMARD: conventional disease-modifying anti-rheumatic drugs; F: female; NSAID: non-steroidal anti-inflammatory drugs; PASI: Psoriasis Area and Surface Index; PsA: psoriatic arthritis; PtGA: patient global assessment; PtPain: patient assessment of pain; SD: standard deviation; SJC: swollen joint count; TMJ: temporomandibular joint; TJC: tender joint count; US: ultrasound.

Table III. Univariate analysis of the two subgroups of patients studied reporting how each variable is distributed among US-documented TMJ synovitis *vs*. no synovitis.

Demographic information	PsA patients with US Synovitis (n=95)	PsA patients with Normal US (n=47)	*p*-value
Age (years, mean ± SD)	58 ± 9.4	56.8 ± 12.6	0.556
F, n (%)	48 (70.6%)	20 (29.4%)	0.379
BMI, mean ± SD	25.3 ± 3.1	26.2 ± 4.4	0.255
Rheumatological disease features			
Disease duration (years, mean ± SD)	7.5 ± 6	10.5 ± 9.1	0.056
PsA subset, n (%)			
Peripheral arthritis	35 (74.5%)	12 (25.5%)	0.191
Enthesitic	22 (95.7%)	1 (4.3%)	**0.001**
Dactylitic	1 (100%)	0 (0%)	1
Axial	4 (80%)	1 (20%)	1
Peripheral (any subset) + axial	3 (75%)	1 (25%)	1
Psoriasis, n (%)	45 (71.4%)	18 (28.6%)	0.366
Therapies, n (%)			
None	2 (25%)	6 (75%)	**0.016**
Only NSAID or steroids	7 (70%)	3 (30%)	1
Only cDMARD	69 (69.7%)	30 (30.3%)	0.333
Only bDMARD	13 (76.5%)	4 (23.5%)	0.426
cDMARD + bDMARD	4 (50%)	4 (50%)	0.44
Comorbidities, n (%)			
Cardiovascular	50 (69.4%)	22 (30.6%)	0.594
Hypertension	38 (77.6%)	11 (22.4%)	0.061
Type 2 diabetes	6 (54.5%)	5 (45.5%)	0.505
Dyslipidaemia	18 (58.1%)	13 (41.9%)	0.282
Hyperuricaemia	3 (60%)	2 (40%)	1
Metabolic syndrome	0 (0%)	1 (100%)	0.331
TMJ symptoms, n (%)			
Subjective reported symptoms	27 (87.1%)	4 (12.9%)	**0.009**
Objective signs (*e.g*. pain. jaw sounds)	35 (89.7%)	4 (10.3%)	**<0.001**
Clinimetric indexes			
BASFI, mean ± SD	2.23 ± 2	1.63 ± 1.84	**0.048**
BASDAI, mean ± SD	4.03 ± 2.26	3.21 ± 2.34	0.052
BASDAI <2.8, n (%)	39 (63.9%)	22 (36.1%)	0.586
BASDAI 2.8 <4, n (%)	7 (46.7%)	8 (53.3%)	0.087
BASDAI ≥4, n (%)	48 (75%)	16 (25%)	0.074
ASDAS-PCR, mean ± SD	2.07 ± 1.03	1.91 ± 1.14	0.556
ASDAS <1.3, n (%)	17 (56.7%)	14 (35.9%)	0.691
ASDAS 1.3 <2.1, n (%)	17 (56.7%)	13 (43.3%)	0.194
ASDAS 2.1 <3.5, n (%)	43 (76.8%)	13 (23.2%)	**0.046**
ASDAS ≥3.5, n (%)	8 (57.1%)	6 (42.9%)	0.55
DAPSA, mean ± SD	8.18 ± 7.87	7.19 ± 7.05	0.237
DAPSA ≤4, n (%)	32 (58.2%)	23 (41.8%)	1
DAPSA 5–14, n (%)	44 (74.6%)	15 (25.4%)	0.108
DAPSA 15–28, n (%)	15 (62.5%)	9 (37.5%)	0.639
DAPSA >28, n (%)	4 (100%)	0 (0%)	0.302
PASI, mean ± SD	2.93 ± 4.34	2.33 ± 4.01	0.298
PASI <10, n (%)	88 (67.7%)	42 (32.3%)	0.478
PASI 10–15, n (%)	0 (0%)	4 (100%)	**0.011**
PASI >15, n (%)	5 (100%)	0 (0%)	0.17
PCR (mg/L), mean ± SD	4.59 ± 6.38	4.11 ± 4.20	0.944
SJC, mean ± SD	0.54 ± 0.89	0.43 ± 1.17	0.19
TJC, mean ± SD	1.19 ± 2.48	0.81 ± 1.96	0.16
PtGA (0-10), mean ± SD	3.12 ± 2.61	2.78 ± 2.64	0.413
PtPain (0-10), mean ± DS	3.01 ± 2.44	2.85 ± 2.58	0.597

Statistically significant results are highlighted in the *p*-value column.
ASDAS: Ankylosing Spondylitis Disease Activity Score; BASDAI: Bath Ankylosing Spondylitis Disease Activity Index; BASFI: Bath Ankylosing Spondylitis Functional Index; BMI: Body Mass Index; CRP: C-reactive protein; DAPSA: Disease Activity Index for PSoriatic Arthritis; bDMARDs: biological disease-modifying anti-rheumatic drugs; cDMARD: conventional disease-modifying anti-rheumatic drugs; F: female; NSAID: non-steroidal anti-inflammatory drugs; PASI: Psoriasis Area and Surface Index; PsA: psoriatic arthritis; PtGA: patient global assessment; PtPain: patient assessment of pain; SD: standard deviation; SJC: swollen joint count; TMJ: temporomandibular joint; TJC: tender joint count; US: ultrasound.

activity defined with ASDAS value between 2.1 and 3.5 (76.8% *vs*. 23.2%; *p*=0.046) seem to be more associated with US-TMJ synovitis. Interestingly, in our cohort, moderate PASI index was observed more frequently in the population without TMJ synovitis (0% *vs*. 100%; *p*=0.011).

The univariate analysis conducted between the subgroups with and without active US-TMJ synovitis according to power Doppler signal, confirmed again, a more prominent enthesitic involvement (72.2% *vs*. 27.3%; *p*=0.007), and a frequent peripheral arthritic involvement (62.9% *vs*. 37.1%; *p*=0.019) in the group with active PD TMJ synovitis.

With reference to clinimetric tools, in this subanalysis, Disease Activity index for PSoriatic Arthritis (DAPSA) (10.18±8.13 *vs*. 6.76±7.29; *p*=0.006), Patient Assessment of Pain (PtPain) (3.80±2.55 *vs*. 2.33±2.14; *p*=0.005), and particularly painful joints count (TJC) (2.02±3.23 *vs*. 0.47±1.22; *p*=0.003) and swollen joints count (SJC) (0.77±1 *vs*. 0.33±0.73; *p*=0.023), also proved higher in those with active PD-US TMJ involvement compared to those without.

Table V shows multivariate analysis: the only variable independently associated with the diagnosis of US-documented TMJ synovitis appeared to be enthesitis, while not only enthesitis, but also DAPSA value, TJC, and PtPain correlated with a diagnosis of active PD TMJ synovitis.

TMJ erosions at US were detected in 26/142 patients (18.3%), and among them only 3/26 patients presented symptoms and signs of TMD, 3/26 patients only signs of TMD at Maxillofacial examination, and 20/26 patients presented no symptoms or signs of TMD (Suppl. Fig. S5). In 111 asymptomatic patients, 23 reported TMJ erosions (20.7%), while in 31 symptomatic patients, erosions were detected in 3 of them (9.6%). Supplementary Figure S6 shows the distribution of symptomatic and asymptomatic patients among erosive *versus* non erosive TMJ US examination, however it does not reach statistical significance.

Discussion

The prevalence of TMJ involvement in PsA is not fully known to date.

Table IV. Univariate analysis of the two subgroups of patients studied reporting how each variable is distributed among PD active TMJ synovitis *vs*. TMJ synovitis without PD signal).

Demographic information	PsA Patients with PD+ US-synovitis (n=44)	PsA Patients with PD- US-Synovitis (n=51)	*p*-value
Age (years, mean ± SD)	57.3 ± 11.5	58.6 ± 7.2	0.478
F, n (%)	24 (50%)	24 (50%)	0.539
BMI, mean ± SD	25.7 ± 3.1	25 ± 3.1	0.257
Rheumatological disease features			
Disease duration (years, mean ± SD)	7.3 ± 4.4	7.6 ± 7.1	0.607
PsA subset, n (%)			
Peripheral arthritis	22 (62.9%)	13 (37.1%)	**0.019**
Enthesitic	16 (72.7%)	6 (27.3%)	**0.007**
Dactylitic	0 (0%)	1 (100%)	1
Axial	3 (75%)	1 (25%)	0.333
Peripheral (any subset) + axial	3 (100%)	0 (0%)	0.096
Psoriasis, n (%)	19 (42.2%)	26 (57.8%)	0.679
Therapies, n (%)			
None	1 (50%)	1 (50%)	1
Only NSAID or steroids	2 (28.6%)	5 (71.4%)	0.445
Only cDMARD	36 (52.2%)	33 (47.8%)	0.07
Only bDMARD	5 (38.5%)	8 (61.5%)	0.766
cDMARD + bDMARD	0 (0%)	4 (100%)	0.121
Comorbidities, n (%)			
Cardiovascular	25 (50%)	25 (50%)	0.53
Hypertension	17 (44.7%)	21 (55.3%)	0.836
Type 2 diabetes	3 (50%)	3 (50%)	1
Dyslipidaemia	9 (50%)	9 (50%)	0.769
Hyperuricaemia	3 (100%)	0 (0%)	0.096
Metabolic syndrome	0 (0%)	0 (0%)	-
TMJ symptoms, n (%)			
Subjective reported symptoms	15 (55.6%)	12 (44.4%)	0.266
Objective signs (*e.g*. pain. jaw sounds)	19 (54.3%)	16 (45.7%)	0.288
Clinimetric indexes			
BASFI, mean ± SD	2.44 ± 1.93	2.06 ± 2.06	0.234
BASDAI, mean ± SD	4.3 ± 2.26	3.8 ± 2.27	0.31
BASDAI <2.8, n (%)	13 (33.3%)	26 (66.7%)	0.059
BASDAI 2.8 <4, n (%)	5 (71.4%)	2 (28.6%)	0.24
BASDAI ≥4, n (%)	25 (52.1%)	23 (47.9%)	0.222
ASDAS-PCR, mean ± SD	2.04 ± 0.97	2.1 ± 1.07	0.896
ASDAS <1.3, n (%)	11 (44%)	14 (56%)	1
ASDAS 1.3 <2.1, n (%)	9 (52.9%)	8 (17.1%)	0.592
ASDAS 2.1 <3.5, n (%)	20 (46.5%)	23 (53.5%)	0.837
ASDAS ≥3.5, n (%)	2 (25%)	6 (75%)	0.287
DAPSA, mean ± SD	10.18 ± 8.13	6.76 ± 7.29	**0.006**
DAPSA ≤4, n (%)	10 (31.2%)	22 (68.8%)	**0.05**
DAPSA 5–14, n (%)	22 (50%)	22 (50%)	0.541
DAPSA 15–28, n (%)	10 (66.7%)	5 (33.3%)	0.098
DAPSA >28, n (%)	2 (50%)	2 (50%)	1
PASI, mean ± SD	2.14 ± 2.78	3.59 ± 5.24	0.403
PASI <10, n (%)	42 (47.3%)	46 (52.3%)	0.062
PASI 10–15, n (%)	0 (0%)	0 (0%)	-
PASI >15, n (%)	0 (0%)	5 (100%)	0.062
PCR (mg/L), mean ± SD	4 ± 3.17	5.08 ± 8.16	0.234
SJC, mean ± SD	0.77 ± 1	0.33 ± 0.73	**0.023**
TJC, mean ± SD	2.02 ± 3.23	0.47 ± 1.22	**0.003**
PtGA (0-10), mean ± SD	3.65 ± 2.56	2.66 ± 2.58	**0.05**
PtPain (0-10), mean ± DS	3.80 ± 2.55	2.33 ± 2.14	**0.005**

Statistically significant and borderline results are highlighted in the *p*-value column.
ASDAS: Ankylosing Spondylitis Disease Activity Score; BASDAI: Bath Ankylosing Spondylitis Disease Activity Index; BASFI: Bath Ankylosing Spondylitis Functional Index; BMI: Body Mass Index; CRP: C-reactive protein; DAPSA: Disease Activity Index for PSoriatic Arthritis; bDMARDs: biological disease-modifying anti-rheumatic drugs; cDMARD: conventional disease-modifying anti-rheumatic drugs; F: female; NSAID: non-steroidal anti-inflammatory drugs; PASI: Psoriasis Area and Surface Index; PsA: psoriatic arthritis; PtGA: patient global assessment; PtPain: patient assessment of pain; SD: standard deviation; SJC: swollen joint count; TMJ: temporomandibular joint; TJC: tender joint count; US: ultrasound.

In our series, we found a prevalence of subjective symptoms and objective clinical signs of TMJ involvement of 22% and 28%, respectively, which appears lower than that described in literature in PsA cohorts. However, this prevalence appears to be underestimated as it must be considered that of the 142 PsA patients included in the study, 8 were in stable remission without therapy, while 106 patients were under pharmacological treatment and presented a disease that was either not very active or in remission; only 28 patients had high disease activity.

Epidemiological studies of TMJ involvement in PsA are few (20-25) and data emerging from published cases are rather discordant because of the differences both in the number of the sample examined and among the characteristics of the disease (duration of illness, drugs used, diagnostic criteria, etc.). However, we certainly know today that TMJ involvement in PsA is more frequent than originally believed and that it may be particularly severe, with a greater tendency to ankylosis (26). In a series of 110 patients with PsA, Kononen *et al*. highlighted a prevalence of subjective symptoms and objective clinical signs of TMJ involvement of 62% (21) and 90% in a subsequent study (22) respectively, showing percentage significantly higher than observed in the general adult population (about 33%) (27). In two others small series of patients, the prevalence of subjective symptoms and objective clinical signs of TMJ involvement was respectively of 35% and 62% (in 20 PsA patients) (24) and of 80% and 62.7% (in 25 patients) (25). Confirming the aggressive potential of US-TMJ synovitis in PsA, the study by Wenneberg *et al*. documented the presence of condylar erosive changes in 38% of PsA subjects, as documented through radiographic images (23) .

Thanks to the high-frequency probes available today and the application of power Doppler, osteoarticular US has proved to be a more sensitive method than clinical examination in disclosing inflammatory alterations of the joint and muscle-tendon structures which escape clinical examination in rheumatic inflammatory diseases (28). In

Table V. Multivariate analysis.

Variable	OR	CI 95%	*p*-value
TMJ synovitis *vs*. normal US			
Enthesitis	14.5	1.891–112.497	**0.01**
Active TMJ synovitis at PD *vs*. TMJ synovitis without PD signal			
DAPSA (value)	0.704	0.563–0.881	**0.002**
TJC	2.569	1.379–4.786	**0.003**
PtPain	1.892	1.208–2.963	**0.005**
Enthesitis	6.124	1.465–25.592	**0.013**

CI: confidence interval; DAPSA: Disease Activity index for PSoriatic Arthritis; OR: odds ratio; PD: power Doppler; PtPain: patient assessment of pain; TJC: tender joint count; US: ultrasound.

our study the employment of US allowed to detect a high prevalence of TMJ involvement in PsA, revealing the presence of alterations even in clinically asymptomatic patients (65 with US abnormalities out of 111 PsA patients with no TMJ symptoms, and 57 with US abnormalities out of 103 PsA patients without clinical signs of TMJ involvement). Even PD-US unveiled the presence of inflammatory signs in 29 patients out of 111 PsA patients with no TMJ symptoms, and in 25 patients out of 103 PsA patients without clinical signs of TMJ involvement. These data confirmed that US was more sensitive than clinical-objective examination in detecting TMJ synovitis, possibly leading to a more precise estimate of the real prevalence of TMJ involvement in PsA. TMJ inflammation, in fact, is rarely symptomatic in early stages, because the retrodiscal tissue structure of TMJ joint is rich in blood vessels, which contribute to the resorption of joint effusion (29). It is therefore likely to speculate that the wide variability in prevalence, as reported in literature, reflects the way TMD is defined, and it is reasonable to assume that a fair proportion of patients come to medical attention when TMJ damage has already been established and become manifest.

As above mentioned, in our study, we recorded a lower percentage of patients presenting with clinical signs and symptoms of TMD compared with other PsA case series. This is probably not only a mere consequence of the fact that most of the patients were under immunosuppressant therapy, reaching established well-controlled disease; in our work, TMJ clinical assessment was performed by a rheumatologist (as in other analogue studies) and by a TMJ expert maxillofacial surgeon. This is an added value, since our results are more reliable in terms of clinical prevalence. In fact, in literature study cohorts the examination is very frequently conducted by a rheumatologist alone, who is not necessarily sufficiently knowledgeable about TMD, and may 'overestimate' TMJ involvement, whereas the maxillofacial surgeon's evaluation is more accurate.

Moreover, in the control population, degenerative changes (in terms of reduction of cartilage thickness) prevailed over non-inflammatory changes. However, the prevalence of degenerative changes found in our PsA cohort did not differ statistically from the control group.

In our study, we also examined whether certain PsA disease clinical features and clinimetric data correlated with US TMJ involvement in order to profile a subset of PsA patients at risk of TMJ involvement, useful to set up ahead screening and targeted follow-up.

Thus far, the duration of the disease, the severity and the number of affected joints represent the main risk factors for possible involvement of the TMJs in the course of PsA (21, 22, 27).

In our study, peripheral, and especially enthesitic involvement were associated with a significantly considerable frequency of US-TMJ synovitis. Clinimetric tools developed to assess peripheral joint involvement (namely, ASDAS score) also emerged to be associated with higher proportion of TMJ involvement at univariate analysis. Pt Pain values, SJC and DAPSA rate were significantly more elevated in PsA subgroup presenting active PD-US TMJ synovitis compared with TMJ synovitis group without PD signals. At multivariate analysis, enthesitis was reconfirmed as an independent variable associated with both the presence of TMJ synovitis alone and the presence of active TMJ synovitis based on PD signal.

It is still a matter of debate whether TMJ involvement should be considered as axial or peripheral subset. To the best of our knowledge, only one previous study (30) evaluated the relationship between TMD and axial or peripheral involvement in rheumatic diseases, highlighting a more significant TMJ uptake at bone scintigraphy in patients with axial involvement. In our work, BASFI, a disability score upon axial involvement, was significantly higher in patients with US-TMJ synovitis. However, it was not found to be independently associated with TMD diagnosis on multivariate analysis. Notwithstanding, it should be strengthened that in our case series, only few patients (3.5% among the total) displayed axial involvement, a minority in our study population.

Enthesitic involvement turns out to be the only variable independently linked with the diagnosis of US-TMJ synovitis (and positive PD synovitis) even on multivariate analysis. This certainly represents a compelling finding, although other studies on JIA have not confirmed the result (31), or even other reports postulated a negative association between TMD and enthesitic involvement (32). Entheses are rich in type I collagen fibres, transitioning in both geometry and composition before inserting into the bone (33). The TMJ exerts a wide range of motion through the insertion of the temporalis, masseter, external and internal pterygoid muscle on the jaw, and such an insertion constitute an enthesis (34). Enthesis is often the primary injury site of early SpA, following repeated microtrauma (35), causing the release of local pro-inflammatory cytokines (36). TMJ is certainly prone to repeated mechanical stress, which could promote

the development of local enthesitis. Moreover, recent studies support the tendinous origin of the TMJ disc: it has been shown that, like the TMJ disc, the fibrocartilaginous cells of the TMJ enthesis would derive from Hedgehog signalling (37). These are of course still hypotheses under study, but from a speculative point of view, if confirmed, they could explain the strong association between enthesitic involvement of PsA and TMD.

A correlation between the presence of symptoms and signs of TMD and US-documented TMJ synovitis also emerged. In contrast, no correlation between symptoms and signs of TMD and rates of positive PD TMJ synovitis was found, underscoring how the mere presence of clinical picture evocative for TMD might not be adequate, alone, to identify the more severe manifestations of TMJ involvement, more prone to damage progression. In this context, US could acquire a pivotal role in identifying TMJ inflammatory pathology not only in asymptomatic patient, before clinical manifestation, but also in patients at risk of TMJ involvement, allowing further investigation and best treatment options.

Finally, PASI values reflecting moderate skin disease activity were less related to TMJ synovitis, an observation partially contrasting with other studies, such as the work of Crincoli (25). However, the majority of our study population presented limited skin involvement, which may constitute a possible bias. Nonetheless, like our study, few other reports in literature have demonstrated no relationships between skin picture severity and TMJ involvement (24, 38).

In our study, we did not administered TMJ anamnestic questionnaires, such as the Fonseca score (39), deliberately to avoid patient reported symptoms overrepresentation, rather focusing on the added value of objective data, to overcome the existing wide diagnostic uncertainties around TMD management.

A limitation of the present study relies on the wide confidence intervals shown in the multivariate logistic regression results, as this is a limited patient sample. Studies with larger case series upon the relationship between rheumatic diseases and TMD are certainly needed. However, it should be emphasised that, to the best of our knowledge, our cohort focusing on TMJ involvement in PsA is currently the one with the largest population number in literature.

In conclusion, our results emphasise that peripheral involvement (predominantly enthesitic), may be associated with US-TMJ synovitis development. Furthermore, ultrasonography may acquire a relevant role in early TMDs diagnosis and in subclinical forms, eventually replacing MRI massive employment, particularly in Outpatient Department and low-income settings, retaining MRI to suspicious US-documented cases. Nonetheless, it should be borne in mind that MRI remains, to date, the gold standard of TMD diagnosis.

Further studies with larger cohorts are certainly needed. In particular, it would be of great importance to discriminate which US sign may be more evocative of inflammatory TMJ involvement, instead of degenerative (as largely observed in the general population and not only in the rheumatological population). On the basis of the experience gained at our Clinic, we also believe that close collaboration between rheumatologists and maxillofacial surgeons in TMJ evaluation of patients is imperative in order to ensure appropriate care and follow-up management of both inflammatory and, inevitably and consequently, mechanical and degenerative complications caused by TMJ involvement.

Key messages

- Patients with psoriatic arthritis are likely to experience TMD, even if clinically asymptomatic.
- Enthesitic subset may exhibit higher rate of TMJ involvement.
- TMJ US may detect asymptomatic patients, leading to prompt and appropriate treatment.

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