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Importance of Relative Comparison of Capsular Widths on the Affected and Non-Affected Sides of Temporomandibular Joint Arthralgia Patients: An Ultrasonography Study

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Purpose: In this study, we evaluate the potential of the relative ratio of capsular width (RCW) between the affected side (Aff) and non-affected side (Non-aff) in patients with temporomandibular joint (TMJ) arthralgia. We assessed whether RCW may hold greater diagnostic significance than the objective capsular width (CW) reported in previous studies when diagnosing arthralgia using ultrasonography (US).

Methods: Forty-nine patients were assessed using US, excluding four patients with bilateral arthralgia. The patients were divided into two groups: 40 with unilateral arthralgia (UA), and nine without arthralgia (NA). We measured CW and masseter muscle thickness using US. Moreover, we employed RCW to analyze the variances between the groups. The numerical rating scale (NRS) and RCW were compared before and after dexamethasone injection in 10 patients who underwent follow-up evaluations.

Results: Within the UA group, CW on the Aff was found to be significantly larger compared to the Non-aff ($p<0.001$). Additionally, RCW in the UA group was greater than that in the NA group ($p<0.01$). Furthermore, after dexamethasone injection, a reduction in the NRS and RCW values was observed in the 10 patients who were followed up.

Conclusions: While previous studies have suggested a link between arthralgia and TMJ effusion, making CW a possible indirect diagnostic indicator for arthralgia, our findings propose that RCW could hold more diagnostic value than objective CW. However, additional studies are required to standardize the protocols for interpreting US results and determining the cutoff value of RCW in diagnosing TMJ arthralgia.

Keywords: Arthralgia; Effusion; Temporomandibular joint; Temporomandibular joint disorders; Ultrasonography

INTRODUCTION

Temporomandibular joint disorder (TMD) ranks as the second most common musculoskeletal disease after chronic low back pain, affecting an estimated 5%-12% of the global population, and significantly impacting individuals' daily lives and quality of life [1]. TMD symptoms typically manifest as joint pain, joint noise, and restricted mandibular movement. Specifically, facial pain localized to the temporomandibular joint (TMJ) often results from joint

inflammation, leading to joint effusion [2-4]. This connection between arthralgia and joint effusion has been the focus of numerous studies [4-9].

Magnetic Resonance Imaging (MRI) is considered the gold standard for diagnosing TMD, given its ability to visualize soft tissue structures and the articular disc. However, due to the disadvantages of MRI, such as its high costs, time consumption, and unsuitability for patients with claustrophobia or pacemakers, an alternative imaging technique is necessary [10]. Recent studies have suggested high-resolution ultrasonography (US) (using a transducer of at least 7.5 MHz or higher) as a viable substitute, as it is non-invasive, inexpensive, more comfortable for patients, and offers real-time imaging [9,11-15].

Several studies have investigated the sensitivity and specificity of US by comparing MRI and ultrasound images. Consequently, they have advocated that an indirect evaluation of joint effusion can be achieved by measuring the capsular width (CW) on ultrasound [4,7-9]. However, previous studies have shown that the clinically relevant threshold of CW varies from 1.65 mm to 2.05 mm [4,7-9], highlighting the need for alternative criteria. Therefore, we introduce the concept of the relative ratio of capsular width (RCW), which can be obtained by dividing the CW on the affected side (Aff) by that on the non-affected side (Non-aff) within a single patient, rather than relying on an absolute comparison of CW between different patients.

In this study, we evaluate the importance of comparing CW on the Aff and Non-aff in patients with TMJ arthralgia. Based on the relationship between TMJ effusion and TMJ arthralgia, unlike previous studies that observed only the absolute value of CW, we observed RCW within one patient to address the vast variations observed in CW.

MATERIALS AND METHODS

1. Study Participants and Design

This study received approval from the Institutional Review Board of Pusan National University Dental Hospital, Yangsan (IRB No. PNUDH 2023-08-005-001), and adhered to the principles of the Declaration of Helsinki for Human Studies. Written informed consent was obtained from all patients or their parents upon their first visit, depending on the patient's age. The study comprised patients who visited the Department of Oral Medicine at Pusan National University from September 2022 to July 2023 and underwent ultrasound diagnostic imaging. Diagnoses were made based on the Diagnostic Criteria for Temporomandibular Disorder (DC/TMD), patient history, and clinical examinations [1]. Panoramic and transcranial radiographs were taken to evaluate the gross anatomy and function of the TMJ, with CBCT being conducted as required. Clinical assessments included joint and muscle palpation, joint sound assessment, mandibular range measurement, and the oral behavior checklist (OBC) questionnaire was administered to explore habits associated with arthralgia. From an initial pool of 53 patients, 49 were included in the study, excluding four patients with bilateral arthralgia. Exclusion criteria encompassed any history affecting anatomical structures, such as the TMJ and muscles, prior trauma, hypersensitivity to ultrasound gel, and the absence of initial diagnosis chart records and ultrasound [7]. Clinical aspects, such as sex, age, presence of OA, medication, and dexamethasone injection, were investigated. In addition, joints were classified based on pain, with CW measured in 40 painful TMJs (PT) and 53 painless TMJs (LT). According to the presence of arthralgia, the 49 included patients were assigned to either the unilateral arthralgia (UA) group (n=40) or the patient without arthralgia (NA) group (n=9). US were performed on the patients, and CW and masseter muscle thickness (MMT) were compared across the groups. Within the UA group, joints were classified as Aff or Non-aff, and within the NA group, joints were classified as left and right sides. Additionally, RCW and the relative ratio of masseter muscle thickness (RMMT), which can be obtained by dividing the MMT on the Aff by that on the Non-aff, were compared. Eleven of the 49 patients were followed up, and multiple US sessions were conducted on the same patient, with dexamethasone injections given to all but one. US were performed before and after the patient's injection, allowing for comparisons of the numerical rating scale (NRS) and RCW.

2. Ultrasonography of the Capsular width and Masseter Muscle Thickness

An ultrasound imaging device, V8 (Samsung Medison), equipped with a linear array transducer (2-14 MHz,

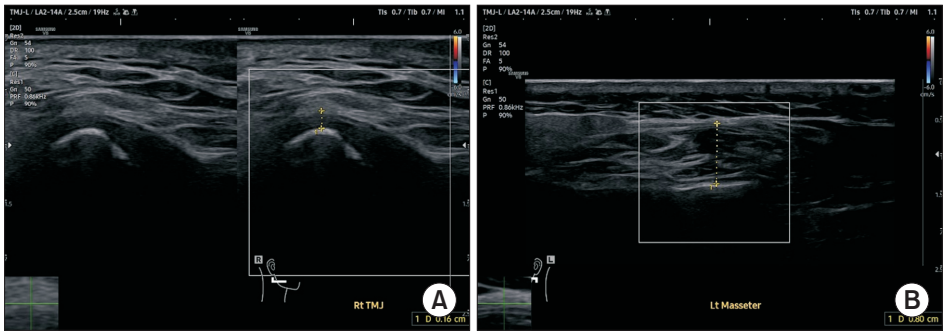

Fig. 1. Ultrasonic images of the articular capsule and masseter muscle. (A) Transverse ultrasonic scan of the right temporomandibular capsular width. The two points (+) were placed above the condylar fossa (upper point) and the condylar laterosuperior surface (lower point). (B) Transverse ultrasonic scan of left masseter muscle thickness. Rt., right; TMJ, temporomandibular joint; Lt., left.

Table 1. Clinical characteristics of the patients included in the study

Variable	UA	NA	p-value
Sex			
Male	11	3	0.726
Female	29	6	
Age	44.83±19.76	40.22±13.80	0.420
OA			
OA	26	4	0.253
Control	14	5	
Medication			
Patients treated with medication	23	5	0.915
Patients without medication	17	4	
Dexamethasone injection			
Patients treated with dexamethasone injection	25	2	
Patients without dexamethasone injection	15	7	
OBC			
1. Clench or grind teeth when asleep, based on any information you may have	2.15±1.55	2.38±1.92	0.945
2. Sleep in a position that puts pressure on the jaw	2.74±1.65	3.00±1.51	0.708
3. Grind teeth together during waking hours	1.00±0.00	1.13±0.35	0.588
4. Clench teeth together during waking hours	1.51±0.82	1.75±0.71	0.321
5. Press, touch, or hold teeth together other than while eating	1.54±0.85	2.38±0.92	0.022*
6. Hold, tighten, or tense muscles without clenching or bringing teeth together	1.74±1.09	2.00±1.31	0.569
7. Hold or jut jaw forward or to the side	1.33±0.66	1.75±0.89	0.234
8. Press tongue forcibly against teeth	1.36±0.81	1.75±1.39	0.461
9. Place tongue between teeth	1.31±0.77	1.75±1.39	0.395
10. Bite, chew, or play with your tongue, cheeks, or lips	1.44±0.79	1.88±1.13	0.308
11. Hold jaw in rigid or tense position, such as to brace or protect the jaw	1.21±0.91	1.50±1.41	0.765
12. Hold between the teeth or bite objects such as hair, pipe, pencil, pens, fingers	1.05±0.32	1.25±0.71	0.667
13. Use chewing gum	1.36±0.78	1.50±0.76	0.588
14. Play musical instrument that involves use of mouth or jaw	1.23±0.90	1.00±0.00	0.749
15. Lean with your hand on the jaw, such as cupping or resting the chin in the hand	1.90±1.23	1.88±0.99	0.728
16. Chew food on one side only	2.79±1.47	2.13±1.25	0.223
17. Eating between meals	2.22±1.03	2.13±0.99	0.988
18. Sustained taking	2.15±1.37	2.38±1.06	0.495
19. Singing	1.49±0.79	1.50±0.93	0.923
20. Yawning	2.46±0.88	2.75±0.89	0.478
21. Hold telephone between your head and shoulders	1.33±0.662	1.38±0.74	0.967
Sum	35.18±8.69	34.78±16.76	0.946

UA, patients with unilateral arthralgia; NA, patients without arthralgia; OA, osteoarthritis; OBC, oral behavior checklist; Sum, summation of all oral behavior checklist items.
Values are presented as number only or mean±standard deviation.
*p<0.05, Chi-square test, Mann-Whitney U test, independent t-test.

LA2-14A), was employed. TMJ US was performed by a single experienced clinician, with a different investigator interpreting the results while blinded to the clinical investigation. Ultrasound images were acquired with the mouth closed in a centric occlusion state, and the patients were in a supine position on a chair. A linear transducer was placed parallel to the zygomatic arch to capture the best imaging angle [12,16]. The precise location of the TMJ was identified through the opening and closing movement before capture. The boundary of the masseter muscle was identified through image changes during resting and clenching [17]. The articular capsule was directly visualized as a hyperechoic line in US, localizing parallel to the surface of the mandibular condyle, and CW was measured as the distance between that line and the condylar laterosuperior surface with the subject in the closed-mouth position [7,18]. Real-time measurements of CW and MMT were undertaken by an experienced clinician using built-in ultrasound software, and the captured files were transferred to INFINITT PACS M6 (INFINITT Healthcare Co.) for viewing (Fig. 1).

3. Statistical Analysis

Statistical analyses were conducted using IBM SPSS Statistics for Windows, Version 21.0 (IBM Co.). To assess whether the data followed a normal distribution, the Kolmogorov–Smirnov test was conducted before performing any statistical tests. The paired t-test and Wilcoxon signed-rank test were used to compare CW and MMT between Aff and Non-aff in patients with or without arthralgia. Independent t-tests and Mann–Whitney U tests were utilized to compare RCW and RMMT based on the presence of arthralgia. Moreover, the Wilcoxon signed-rank test was conducted for patients who underwent follow-up examinations to compare NRS scores and RCW values before and after dexamethasone injection.

RESULTS

There were no significant differences in clinical factors, such as sex, age, and medication treatment, between the UA and NA groups. However, when examining OBC items, a notable difference emerged for Item 5 (“Press, touch, or hold teeth together other than while eating”), with scores of 1.54±0.85 in the UA group and 2.38±0.92 in the NA group (p=0.022) (Table 1). The CW measurements revealed a difference of 1.62±0.63 mm in PT and 1.31±0.43 mm in LT (Table 2).

Within the UA group, the average CW for Aff was 1.62±0.63 mm, while that for Non-aff was 1.26±0.43 mm, with the width in Aff being significantly larger (p<0.001). However, the mean MMT of Aff and Non-aff stood at 9.55±2.15 mm and 9.83±1.55 mm, respectively, with no discernible difference. Additionally, there was no statistically significant difference in CW and MMT in the NA group (Table 3). The average RCW values for the UA and NA groups were 1.36±0.49 and 0.89±0.23, respectively, marking a significant difference in RCW (p<0.01) but not in RMMT (Table 4).

For patients undergoing follow-up, there was a notable

Table 2. The mean capsular width according to the presence of arthralgia (n=93 joints)

Arthralgia	PT (n=40)	LT (n=53)	p-value
CW	1.62±0.63 (0.7-3.5)	1.31±0.43 (0.5-2.3)	0.021*

PT, painful temporomandibular joint; LT, painless temporomandibular joint; CW, capsular width.
Values are presented as mean±standard deviation (range).
*p<0.05, independent t-test.

Table 3. The mean capsular width and the masseter muscle thickness according to the presence of arthralgia

Presence of arthralgia	UA			NA		
	Aff	Non-aff	p-value	Rt. TMJ	Lt. TMJ	p-value
CW	1.62±0.63	1.26±0.43	<0.001***	1.39±0.55	1.53±0.27	0.348
MMT	9.55±2.15	9.83±1.55	0.408	7.83±1.77	7.15±1.31	0.465

UA, patients with unilateral arthralgia; NA, patients without arthralgia; Aff, affected side; Non-aff, non-affected side; Rt., right; TMJ, temporomandibular joint; Lt., left; CW, capsular width; MMT, masseter muscle thickness.
Values are presented as mean±standard deviation.
***p<0.001, paired t-test, Wilcoxon signed-rank test

Table 4. The mean relative ratio of capsular width and masseter muscle thickness according to the presence of arthralgia

Presence of arthralgia	UA	NA	p-value
RCW	1.36±0.49	0.89±0.23	0.007**
RMMT	0.97±0.15	1.10±0.20	0.288

UA, patients with unilateral arthralgia; NA, patients without arthralgia; RCW, relative ratio of capsular width; RMMT, relative ratio of masseter muscle thickness.
Values are presented as mean±standard deviation.
**p<0.01, Mann-Whitney U test, independent t-test.

Table 5. The mean NRS and the relative ratio of the capsular width before and after dexamethasone injection

Dexamethasone injection	Before	After	p-value
NRS	4.50±2.04	2.86±1.57	0.041*
RCW	1.55±0.39	1.04±0.34	0.003**

NRS, numerical rating scale; RCW, relative ratio of capsular width.
Values are presented as mean±standard deviation.
*p<0.05, **p<0.01, Wilcoxon signed-rank test.

reduction in NRS scores after dexamethasone injection, decreasing from 4.50±2.04 to 2.86±1.57 (p<0.05). Similarly, RCW values before and after injection decreased from 1.55±0.39 to 1.04±0.34, and a statistically significant shift was observed (p<0.01) (Table 5).

DISCUSSION

TMD is a multifactorial disease with parafunctional behaviors that can potentially cause trauma in the masseter muscle and TMJ [1]. The OBC assesses self-reported parafunctional activities during both wakefulness and sleep. According to another study that compared the correlation between the OBC and masseter muscle pain, patients with masseter muscle pain had significantly higher scores on Item 5 ("Press, touch, or hold teeth together other than while eating") compared to pain-free controls [19]. In our study, higher scores were recorded in the NA group than in the UA group, likely because most of the patients in the NA group had myalgia.

Histopathologically, TMJ effusion refers to the excessive accumulation of mucin in the joint due to trauma, internal derangement, and inflammatory changes related to arthritis and rheumatoid diseases [15,20]. Previous studies have shown a possible relationship between joint effusion and arthralgia, with TMJ effusion being directly observed as a hypoechoic region within the joint cavity or inferred by measuring CW [14,18,20]. Kim et al. [7] suggested that CW could be an independent risk factor for TMJ pain. When comparing MRI-depicted TMJ effusions with ultrasonographic measurements of CW, Manfredini et al. [8,18] identified a 2 mm CW as the cutoff point. Conversely, Bas et al. [4] suggested a CW threshold of 1.65 mm. Assaf et al. [11] and Talmaceanu et al. [9] asserted CW values of 1.76 mm and 2.05 mm, respectively, as significant markers. Thus, previous studies have shown a clinically significant threshold for CW, varying from 1.65 mm to 2.05 mm [4,7-9].

Our findings indicated a mean CW of 1.62±0.63 mm in PT and 1.31±0.43 mm in LT, showing significant differences. Despite these differences, we observed cases of arthralgia that fell outside the expected CW range and instances where pain was absent, even when CW thresholds were met. To address these limitations, we shifted our focus from absolute CW values to comparing the CW of Aff and Non-aff within the same patient. This introduced the concept of RCW as a comparative metric, which was notably higher in the UA group. Furthermore, following dexamethasone injection, both NRS scores and RCW showed significant reductions, showing the potential of RCW as a diagnostic and therapeutic indicator. Our study pioneers the use of RCW for diagnosing arthralgia. While the definitive cutoff value for RCW in relation to arthralgia remains inconclusive based solely on this research, it represents a significant first step. This study has limitations, including evaluating TMJ effusion without a direct comparison with MRI, which is considered the gold standard, and a relatively small patient sample. However, it is essential to highlight our results, which indicate that RCW may deviate significantly even with CW values within or below the 1.65 mm to 2.05 mm range.

In conclusion, our findings underscore the significance of RCW over absolute CW in diagnosing TMJ arthralgia. Moreover, through the follow-up of several patients, the decrease in RCW and NRS scores after dexamethasone injection suggests the viability of RCW as an indirect diagnostic and therapeutic indicator. Additional studies are required to standardize the protocols for interpreting US results and

determining the cutoff value of RCW in diagnosing TMJ arthralgia.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

DATA AVAILABILITY STATEMENT

The datasets used in this study are available from the corresponding author upon reasonable request.

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AUTHOR CONTRIBUTIONS

Conceptualization: HWK, HMJ. Methodology: HMJ. Software: HWK. Validation: HWK. Formal analysis: HMJ. Investigation: HMJ. Resources: YWA. Data curation: SHJ, SMO. Visualization: HWK. Writing original draft: HWK. Writing review & editing: HMJ. Supervision & project administration HMJ. Funding acquisition: HMJ.

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