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Efficacy of ultrasonography in diagnosis of temporomandibular joint soft tissue injury induced by mandibular fractures: randomized clinical trial

Eficácia da ultrassonografia no diagnóstico de lesões em tecidos moles da articulação temporomandibular induzidas por fraturas mandibulares: ensaio clínico randomizado

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Abstract

Objective: the aim of this study was to evaluate the efficacy of ultrasonography in diagnosis of tempromandibular joint soft tissue injury after mandibular osteosynthesis.
Material and Methods: ten male patients (20 joint) with age ranged between 20-28 years were collected from those attending the outpatient clinic of Oral and Maxillofacial Surgery Department, Al-Kuwait Hospital, Sana'a University. Patients were divided into two groups according to the number of fracture line in the mandible. All patients were randomly assigned to diagnosis of the soft tissue changes of temporomandibular joint by either ultrasonography or magnetic resonance image preoperatively, after 2 weeks and 3 months postoperatively. **Results:** preoperatively, there was moderate agreement between ultrasonography and magnetic resonance image in the diagnosis of abnormal findings in both groups, the difference was not statistically significant. In group I, ultrasonography of the temporomandibular joint didn't detect any abnormal findings after mandibular osteosynthesis, meanwhile, magnetic resonance image recorded abnormal findings 40% and 20% after 2 weeks and 3 months respectively. In group II, the diagnosis of abnormal findings was the same (80%) pre and postoperatively by using magnetic resonance image however, the percent of abnormal findings was reduced from 60% preoperatively to 40% postoperatively by using ultrasonography. **Conclusion:** the ultrasonographic image was not able to identify or diagnosis the disc position changes after indirect trauma. However, it had to some extent a role in the identification and diagnosis of effusion in temporomandibular joint.

KEYWORDS

Magnetic resonance imaging; Temporomandibular joint; Ultrasonography; Mandibular fractures; Injury.

Resumo

Objetivo: o objetivo deste estudo consistiu em avaliar a eficácia da ultrassonografia no diagnóstico de lesões nos tecidos moles da articulação temporomandibular após a osteossíntese mandibular. **Material e Métodos:** dez pacientes do sexo masculino (no total de 20 indivíduos) de idades entre 20 e 28 anos foram selecionados do serviço ambulatorial do Departamento de Cirurgia Oral e Maxilo-facial, Hospital Al-Kuwait, Universidade de Sana'a. Os indivíduos incluídos foram distribuídos em dois grupos, de acordo com o número de linhas de fratura presentes na mandíbula. Todos os pacientes foram aleatoriamente alocados e divididos, com base no diagnóstico das alterações dos tecidos moles da

articulação temporomandibular por ultrassonografia ou ressonância magnética no pré-operatório e em intervalos de 2 semanas e 3 meses no pós-operatório. **Resultados:** no pré-operatório, houve uma concordância moderada entre a ultrassonografia e a ressonância magnética no diagnóstico de achados anormais em ambos os grupos; a diferença não foi estatisticamente significativa. No grupo I, a ultrassonografia da articulação temporomandibular não revelou quaisquer achados anormais após a osteossíntese mandibular, enquanto a ressonância magnética registou achados anormais em 40% e 20% dos casos após 2 semanas e 3 meses, respectivamente. No grupo II, o diagnóstico das anormalidades por ressonância magnética foi o mesmo (80%) no pré e pós-operatório; contudo, a percentagem de casos anormais por ultrassonografia foi reduzida de 60% no pré-operatório para 40% no pós-operatório. **Conclusão:** a imagem ultrassonográfica não foi capaz de detectar alterações de posição do disco após trauma indireto. Entretanto, em certa medida, contribuiu para a identificação e diagnóstico de efusão na articulação temporomandibular.

PALAVRAS-CHAVE

Ressonância magnética; Articulação temporomandibular; Ultrassonografia; Fraturas mandibulares; Lesão.

INTRODUCTION

The mandibular trauma is one of the etiologic factors in the development of the temporomandibular joint (TMJ) soft tissue changes [1-3]. The diagnosis of temporomandibular joint disorder after trauma is a challenge. Magnetic resonance imaging (MRI) is considered the modality of choice for the evaluation of soft and hard tissues of the TMJ and is the most accurate non-invasive method of visualizing the disc-condyle relation [4-6]. In many institutions MRI was the preferred examination for TMJ soft tissue pathology. The disc position and morphology and the bone structures are clearly visualized on closed and open mouth images on MRI. In recent years MRI has become the standard of reference for the evaluation of the disc-condyle relationship, this allows dynamic assessment of disc, which is often the implicated structure in temporomandibular joint disorders [7-9]. On the other hand, MRI is an expensive examination because of the cost of the equipment, facilities, staffing, and replacement cryogens for the magnet. It is contraindicated in certain patients, such as those with pacemakers, intracranial vascular clips, metal particles in the eye or other vital structures, an implanted or external medication pump, and A cochlear (inner ear) implant. Other relative contraindications include patient obesity, claustrophobia, or an inability to remain motionless for the examination, which may take several minutes to complete examination. For these reasons, this method cannot be classified as a routine examination [10,11]. The use of ultrasonography (US) is an alternative diagnostic method and specific non-invasive technique enabling dynamic imaging of the TMJ. It is capable of demonstrating articular capsule, the disc and the bone boundary of the laterosuperior aspect of the condyle. Moreover, it is cheap, not time consuming, high-resolution, comfortable, available for patients and it can be readily applied without restrictions [10,12]. Alashiry et al. [13], reported that the ultrasonography was less sensitive or specific than was MR imaging in detecting internal derangement in the TMJ. However, internal derangement of the TMJ should be suspected if a distance between the superior surface of the condyle and the inferior surface of the glenoid fossa (disc space) more than 7 mm in closed mouth position and more than 10 mm in opened mouth position. So the significance of ultrasonography as non-invasive and significantly low cost diagnostic technique can be used for patients clinically suspected to have TMJ disorders to exclude the negative results before request the more expensive and invasive images especially in patients with limitation to be examined by MRI such as patients with artificial metallic devices, vascular clips, pacemaker or even during pregnancy. However, US shows agreement with MRI in detecting normal condyle disc relation, anterior disc displacement with reduction (ADDWR), and disc displacement without reduction [14-16]. This study aims to evaluate the efficacy of ultrasonography in diagnosis of tempromandibular joint soft tissue injury after mandibular osteosynthesis.

MATERIAL AND METHODS

Study design

Randomized clinical trials study was conducted in Yemen from April 2019 to March 2020. 20 Patients of the present study were collected from those attending the outpatient clinic of Oral and Maxillofacial Surgery Department, Al-Kuwait Hospital, Sana'a University.

Inclusion and exclusion criteria

Any patient with an age range between 20 and 30 years and had one fracture line or more in the mandible and scheduled for reduction and fixation of the fracture line by miniplate osteosynthesis was included in this study. Patients that have a previous temporomandibular joint disorder, previous surgery in the temporomandibular joint and those that have condylar or sub condylar fractures were excluded from this study. Patients were included according to their commitment to attend the specified periods for clinical and radiological diagnosis, so any patient who did not return for clinical and radiographical evaluations was excluded.

Ethical approval

All of the participants provided written informed consent before they were enrolled in this study. This study was approved by the Sana'a University, Faculty of Dentistry prior to the study IRB Reg. No: 25/ 10-3-2019.

Sampling method

Patients were divided into two groups according to the number of fracture line in the mandible. Group I: patients having one fracture line. Group II: patients having more than one fracture line. Each of both groups was consisted of 5 patients, scheduled for reduction and fixation of fracture line by miniplate osteosynthesis. Both groups of patients were randomly assigned to diagnosis of the soft tissue changes of temporomandibular joint by either ultrasonography or Magnetic resonance image preoperatively, after 2 weeks and 3 months postoperatively.

Clinical oral examination

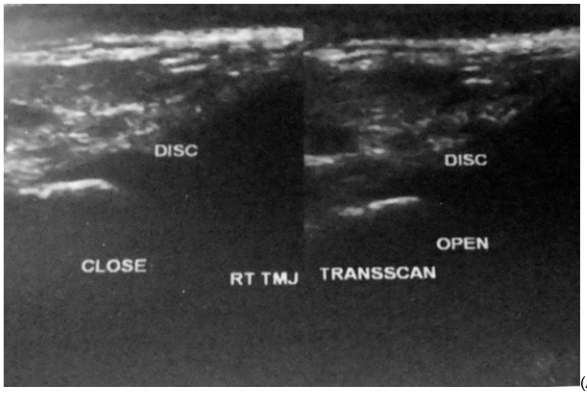
The clinical diagnosis was made by a specialist in oral and maxillofacial surgery. The assessment of the temporomandibular joint in both sides was carried out clinically by asking the patient about any change that he feel after trauma. Palpation of condylar movement as well as measurement of interincisal distance (protrusion, lateral excursions) were taken for each patient [17].

Imaging tests

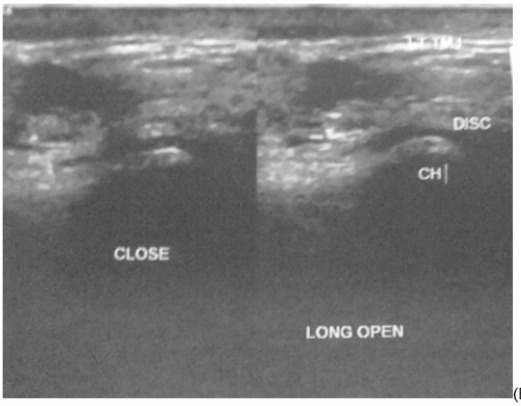
Imaging tests were done by a well experience radiologist at Kuwait Hospital using ultrasonography [13] Figure 1 and Magnetic resonance imaging [9] Figures 2A and 2B to confirm the existed situation of the temporomandibular joint preoperatively and compare it with the postoperative intervals after two weeks and three months. Magnetic resonance imaging was performed on 1.5 teslaiv super conductive magnet (Philips, Gyroscan, Intera, Netherlands) using temporomandibular joint coil. The imaging protocol consisted of temporomandibular joint imaging by utilizaing T1, T2, and proton density images performed in closed mouth, and maximum mouth opening (for both sides). The bite block device was used to stabilize the patient's jaw in the open mouth position. All images were obtained in spin echo technique. The patient was laid in the supine position and resting within the surface coil holders.

The imaging was taken in different planes and different pulse sequences. All patients had T1, T2, and proton density weighed images taken using repetition (TR) and echo (TE) times in magnetic resonance machines.

The coronal images were obtained in planes parallel to the long axis of condyles in the closed mouth position. While, the sagittal scout was planned parallel to the orbitomeatal line at the level of auditory canal.



(A)



(B)

Figure 1 - (A) Transverse and (B) scan ultrasonography in closed and open of temporomandibular joint showing hypoechoic disc appear slightly larger which indirectly indicated effusion.

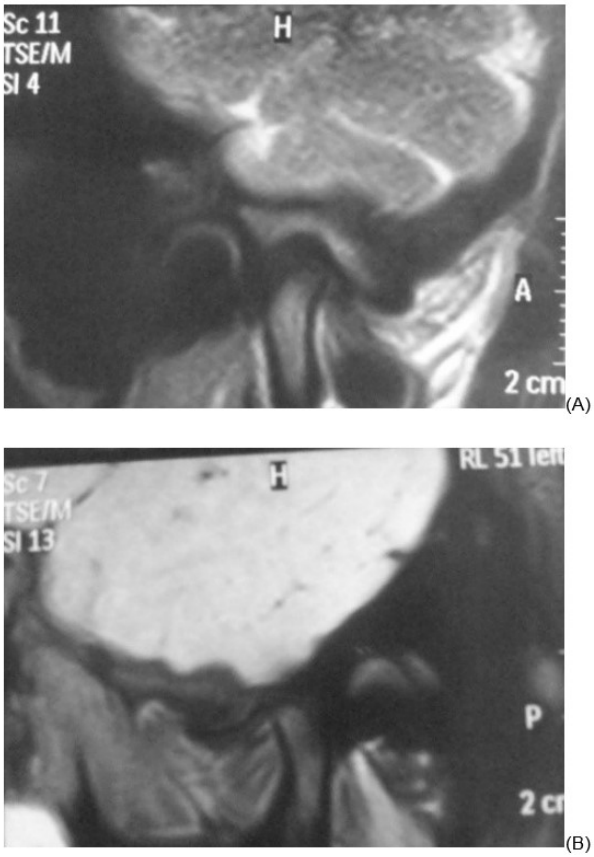


Figure 2 - T2- weighted sagittal image in closed mouth position showing effusion in both sides of temporomandibular joint in group II preoperatively. (A) right side; (B) left side.

The gap or interval between slices was 0.5 to 1.5 mm for the sagittal images, while, for the coronal images it was reduced to about 0.3 mm. T1-weighed images were taken with TR less than 1000 and TE less than 50, while the proton density weighed images were taken with TR more than 1000 and TE less than 50. T2-weighed images were taken with TR more than 1000 and TE more than 80. The slice thickness was 3 mm. Magnetic resonance image findings for soft tissue changes in the temporomandibular joint in the current study where presented in the form of effusion, anterior disc displacement with reduction (ADDWR), limitation of translatory movement, subluxation and thickening in the lateral pterygoid muscle, while ultrasonographic image findings for soft tissue changes where presented only in the form of effusion. Ultrasonographic image Ultrasound (Toshiba, Xario 200) was done using a linear probe of longitudinal and transverse scan, with a frequency of 7.5 MHz. This probe was placed over the TMJ, perpendicular to the zygomatic arch and parallel to the mandibular ramus and tilted until the best view was achieved. This was carried out while the patient set in an upright position, and the transducer positioned against the patient face. Static and dynamic (during movement of condyle) evaluations were usually performed at different mouth opening positions.

Statistical analysis

The statistical package for social sciences (SPSS, IBM, and Chicago, USA version 20.0). The descriptive analysis was presented as mean and standard deviations (SD)

Student's t-test was used to compare between the two groups. Paired t-test was used to study the changes by time within group. Friedman's test was used to study the changes by time in internal derangement findings. Agreement between the two modalities (MRI and US) was tested using Kappa Statistic Kappa statistic values are interpreted as follows; 0-0.2: weak agreement, 0.2-0.4: fair agreement, 0.4-0.6: moderate agreement, 0.6-0.8: good agreement, 0.8-0.99: very good agreement while a value of 1 indicates perfect agreement. The significance level was set at $p \leq 0.05$.

RESULT

At the begging of the study 20 patients were enrolled in this study, 10 patients didn't return for clinical and radiological evaluations at the determined intervals so they were excluded. Preoperatively, MRI showed 1 normal case (20%) and 4 abnormal cases (80%) while US showed 2 normal case (40%) and 3 abnormal cases (60%) Figure 3. There was moderate agreement between ultrasonography and magnetic resonance image in diagnosis of normal and abnormal findings in both groups (Kappa statistic = 0.545), the difference was not statistically significant. In group I, Ultrasonography of the temporomandibular joint didn't detect any abnormal findings after mandibular osteosynthesis (all the cases were normal (100%), however, Magnetic resonance image recorded abnormal findings 40% and 20% after 2 weeks and 3 months respectively Figure 3. Agreement measure (Kappa statistic) could not be computed because all the cases postoperatively were normal by ultrasonography. In group II, MRI showed 1 normal case (20%) and 4 abnormal cases (80%) while US showed 2 normal cases (40%) and 3 abnormal cases (60%) at preoperative period Figure 4. There was

moderate agreement (Kappa statistic = 0.545), however, this agreement was not statistically significant. After 2 weeks, MRI showed 1 normal case (20%) and 4 abnormal cases (80%) while US showed 2 normal cases (40%) and 3 abnormal cases (60%). There was moderate agreement (Kappa statistic = 0.545). However, this agreement was not statistically significant. After 3 months; MRI showed 1 normal case (20%) and 4 abnormal cases (80%) while US showed 3 normal cases (60%) and 2 abnormal cases (40%). There was fair agreement (Kappa statistic = 0.286). However, this agreement was not statistically significant. Within the groups, there was no statistically significant difference between magnetic resonance image findings in the two groups preoperatively, after 2 weeks as well as after 3 months. However, there were two cases in group II that have persisted anterior disc displacement with reduction at the end of the study. While in group I one case was persisted with anterior disc displacement with reduction at the final interval of that study (Table I). There was one case in group I presented with limited translatory movement two weeks postoperatively and disappeared totally by the end of this study. While, in group II there were two cases presented with limited translatory movement preoperatively as well as two weeks postoperative and disappeared at the end of three months interval (Table I).

In comparison between ultrasonography findings in the two groups; there was no statistically significant difference between ultrasonography findings in the two groups preoperatively as well as after 3 months (Table II).

However, after 2 weeks, there was a statistically significant difference between the two groups, the group II showed statistically significant higher prevalence of effusion than Group I. In both MRI and US; effusion was subsided at two weeks and 3 month intervals in group I, there was statistically significant difference within group I. While, the preoperative effusion in group II was persisted at two weeks interval and then slightly reduced at the end of the study, there was no statistically significant difference within group II at different intervals.

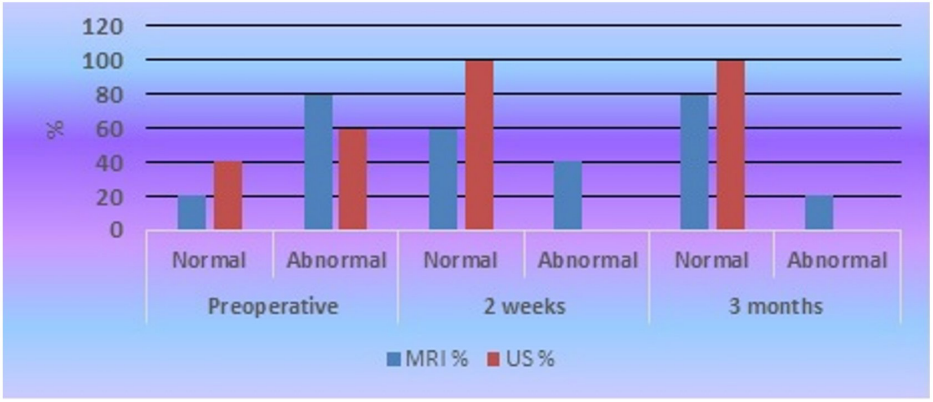


Figure 3 - Agreement between MRI and US findings in Group I.

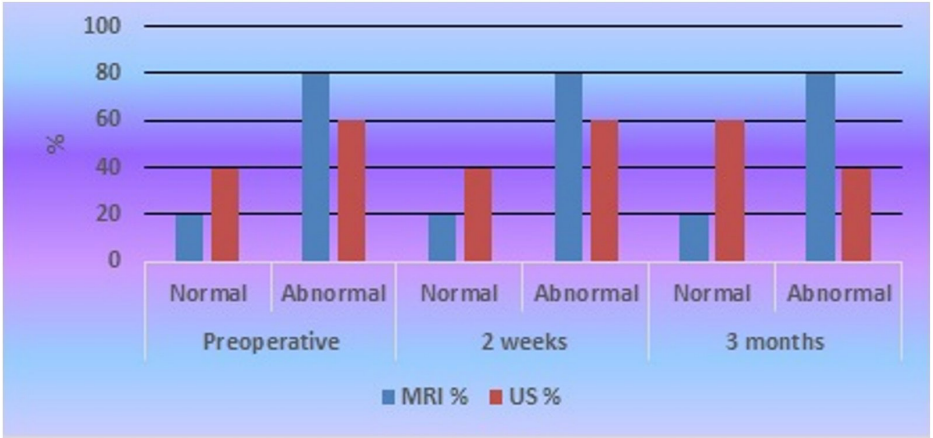


Figure 4 - Agreement between MRI and US findings in Group II.

Table I - Comparison between temporomandibular joint soft tissue changes findings by MRI in two groups

Period	Group / Findings	Group 1		Group 2		*P*-value
		Frequency	%	Frequency	%	
Pre-operative	Effusion	3	60	3	60	1.000
	ADDWR	1	20	1	20	
	Limited translatory movement	0	0	2	40	
	Thickening in lateral pterygoid muscle	0	0	1	20	
	Subluxation	0	0	1	20	
	No change	1	20	1	20	
2 weeks	Effusion	0	0	3	60	0.172
	ADDWR	1	20	1	20	
	Limited translatory movement	1	20	2	40	
	No change	3	60	1	20	
3 months	Effusion	0	0	2	40	0.127
	ADDWR	1	20	2	40	
	No change	4	80	1	20	

*Significant at $p \leq 0.05$.

Table II - Comparison between the temporomandibular joint soft tissue changes findings by US at different time period in two groups

Period	Group / Findings	Group 1		Group 2		*P*-value
		Frequency	%	Frequency	%	
Pre-operative	Effusion	3	60	3	60	1.000
	No change	2	40	2	40	
2 weeks	Effusion	0	0	3	60	0.038*
	No change	5	100	2	40	
3 months	Effusion	0	0	2	40	0.114
	No change	5	100	3	60	
P-value		0.050*		0.368		

*Significant at $p \leq 0.05$.

Additionally, the difference between both groups was not statistically significant (Tables I and II).

DISCUSSION

MRI is a golden tool for imaging the soft tissue of temporomandibular joint [18,19]. The percent of abnormal findings which detected by MRI postoperatively were higher than findings detected by ultrasonography in both groups in this study and at the different observation periods. According to our findings, ultrasonography increases the specificity which refers to the proportion of those who do not have the condition that received a negative result on this diagnostic test, which leads to a minimum number of false-positive diagnoses. While MRI increases the sensitivity, which refers to the proportion of those who have the condition that received a positive result on this diagnostic test, which leads to a minimum number of false-negative diagnose. This was clearly obvious in this study by increasing abnormal cases either before or after the treatment which was detected by MRI and increased normal cases which were detected by US investigation.

The magnetic resonance imaging is the most reliable diagnostic procedure for an objective noninvasive assessment of intracapsular soft tissue and the joint morphology. It has some limitations such as the cost and inavialability. Moreover, the soft tissue of temporomandibular joint can be predicted through using MRI and also has direct proportion to the severity of condylar

injury of the mandible [8]. The effusion was only the soft tissue change in TMJ after indirect trauma. In both US and MRI, there were gradual reducing in the effusion in group I at two weeks until it disappeared at the end of the study (Tables I and II) while it decreased slightly at the three-month interval in group II. This can be explained, due to the more severe trauma in group II that induce much more inflammatory changes in TMJ. This was in agreement with Yun and Kim [1], and Goldberg [2]. However, it was contradicting the study of Yu et al. [3] who reported soft tissue changes in condylar fracture patients only. While it seems to have mild change in cases of trauma without condylar fracture as it was confirmed in this study by both radiographical techniques US and MRI. The performance of US to diagnosis of effusion was similar to performance of MRI. This was in agreement with Yılmaz and Kamburoğlu [19] whose concluded the assessment of anterior disc position and effusion along with highly accurate measurements by ultrasound. However, ultrasonography seems to have some limitations. Unfortunately, one of the major shortcomings of US was abnormal reflection of ultrasound when they intercept hard tissue, added to that the accuracy of US was operator dependent that mean experience of the radiologist to interpret the sonogram may affect the diagnosis [6]. Furthermore, the anatomical characteristics of the temporomandibular joint make interpretation of sonogram very difficult and also the quality of the probe may affect the diagnosis [6]. Persisted three cases with anterior disc displacement with reduction at the final interval of this study as a result of indirect trauma to the TMJ consistent with many studies results which found an association between indirect trauma and disk displacement [7,8]. Disappearing the three cases of limited translatory movement at the end of three months interval (Table I) was explained by either the effect of severance of trauma or the effect of effusion in the soft tissue of TMJ. Then it was disappeared after subsidence of that effusion. Moreover, there were subluxation and thickening in lateral pterygoid muscle in group II preoperatively and disappeared totally by the end of this study. The difference between results depend on the severity of impact force and the status of temporomandibular joint soft tissue before trauma were unknown. whereas the improvement of results are due to the reduction of fracture and healing of soft tissue. Although, ultrasonography was used for imaging and diagnosis of internal derangement of temporomandibular joint [11,16], the present study has proved that the magnetic resonance image was superior than ultrasound in diagnosis of temporomandibular joint soft tissue changes after trauma. MRI seems to provide a clear anatomic picture of soft tissue with temporomandibular joint area specially the disc in sagittal plane. Also it had a high diagnostic accuracy and considered the prime imaging modality for assessment of soft tissue of temporomandibular joint. Unlike MRI, the ultrasound used for imaging and diagnosis of internal derangement of the TMJ was insufficient to detect disc displacement. This was explained by high accuracy of MRI as a golden tool for imaging the soft tissue of temporomandibular joint [19]. While, the anatomical structures of the surrounding bone and the rest of shortcomings of the ultrasound may reduce the accuracy of TMJ soft tissue imaging. This was in accordance with Uysal et al. [4], Katzberg [5], and Bas et al. [16]. Future studies should target a large number of patients and a longer period of follow up.

The sample included only men because the female patients who came with facial bone fractures to the clinic of Oral Maxillofacial Surgery - Al-Kuwait Hospital- Sana'a- Yemen were very rare. This may be due to the conditions of the war in Yemen and the nature of the conservative Yemeni society, which forces women to sit at home (most of the women are housewives). While the most common cause of fractures is traffic accidents.

We recognize that there were some limitations to this study. Most of the patients in the Al-Kuwait Hospital, in Sana'a city, come from rural areas located so far from the capital city which make following them very difficult, so after enrolling 20 patients at the beginning of the study, 10 of these patients didn't come for follow up. Patient education plays a positive role in the of tempromandibular joint soft tissue healing after mandibular osteosynthesis, however patient education was not considered in this study.

CONCLUSION

Ultrasonography has some shortcoming and limitations, this was obvious in both groups and at the different observation periods however, it had a beneficial role in identification and diagnosis of effusion in temporomandibular joint.

Magnetic resonance imaging was proved to have a high quality imaging and still the golden tool for imaging of the temporomandibular joint soft tissue changes.

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Author's Contributions

ATN: Collection the data and writing the methodology. SAD: Analysis the data and writing the duscssion. AHF: Collection the data, analysis the data and writing the manuscript. MSA: Analyzed the data and led the writing. NF: Analysis the data, statistic analysis and writing part of the duscssion.

Conflict of Interest

The authors declare that they have no conflict of interests. Funding The authors declare that no financial support was received.

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Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects. A prior permission from the Institutional Review Board at College of Dentistry, Sana'a University, and a signed consent from the patient had preceded the collection of information and interview for the current case report.

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