Oral and Maxillofacial Surgery (2019) 23:159–165
https://doi.org/10.1007/s10006-019-00753-6

ORIGINAL ARTICLE

Ultrasound-guided arthrocentesis using single-puncture, double-lumen, single-barrel needle for patients with temporomandibular joint acute closed lock internal derangement

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Received: 10 August 2018 / Accepted: 21 February 2019 / Published online: 28 March 2019

Abstract

Purpose Temporomandibular joint (TMJ) disc derangement is defined as a malpositioning of the articular disc relative to the condyle and eminence. Arthrocentesis of the TMJ is considered by many as the first-line surgical treatment for patients who do not respond to conservative treatment. The aim of this study is to assist needle insertion for temporomandibular joint arthrocentesis using ultrasonography.

Materials and method Twenty patients who required arthrocentesis of the TMJ were randomly assigned to two groups A and B undergoing single-puncture arthrocentesis with modified double-lumen single-barrel needle and ultrasound-guided single-puncture arthrocentesis using modified double-lumen single-barrel needle ($n = 10$ in each group). The number of attempts of needle manipulation, duration of the operative procedural time, and visual analog (VAS) scale score for pain to assess surgical discomfort were the main outcome variables.

Results None of the patients in either group developed any complication with no significant difference in VAS score for pain between the two study groups. The number of attempts for needle manipulation (mean ± SD) for group A was 2.20 ± 0.789, and for group B, it was 1.10 ± 0.316 (p value, 0.0007); operative procedural time (mean ± SD) for group A was 18.5 ± 3.171 min, and for group B, it was 13.1 ± 1.663 (p value, 0.0002) which was significantly lesser in group A than in group B. The sentence signifies that the number of attempts that was required to re-insert the needle to enter the joint space in Ultrasound guided and conventional method of arthrocentesis.

Conclusion Ultrasound-guided single-puncture arthrocentesis using a customized needle is a promising method to perform joint lavage with minimal trauma and in a precise manner.

Keywords Temporomandibular joint · Internal derangement · Closed lock jaw · Single-puncture arthrocentesis · Ultrasound-guided arthrocentesis · Disc displacement

Introduction

Temporomandibular joint (TMJ) disc derangement is defined as a malpositioning of the articular disc relative to the condyle and eminence [1]. If conservative methods fail, arthrocentesis may be indicated to restore mandibular function [2]. For efficient arthrocentesis of the TMJ, consistent access and lavage are the key factors [3]. The single-needle approach for temporomandibular joint lavage based on the rationale that flushing saline or Ringer's lactate into the superior joint compartment provides enough pressure to release joint adherences and clear the inflammatory concentrates from the joint cavity. The anatomy of TMJ is complex, unsighted technique to reach the superior joint space demands experience, and identification of the superior joint space is essential for successful lavage and lysis. Though literature suggests MRI is the gold standard for clinical diagnostic criteria for the disorders of the TMJ, ultrasound is also effective [4].

Literature have described ultrasonography (USG)-guided peripheral venous access, central venous access, drainage of

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abscesses, aspiration of the hip and shoulder joints, pleural effusions, paracentesis, and TMJ arthrocentesis [5]. The first introduction and application of ultrasound in dentistry was reported in 1953 by Lefkowitz [6]. Amplitude mode (A-mode) and brightness mode (B-mode) of ultrasound are used in dentistry in general. A-mode ultrasound uses a single crystal to generate a one-dimensional image with the echo amplitude, displayed vertically, and the echo time, displayed horizontally. B-mode ultrasound images can be produced by moving an ultrasound probe (transducer) on a trajectory, receiving RF-echo signals from each probe position, and then transforming electrical energy into a light spot using grayscale on a monitor [7, 8].

Visualization of the TMJ and the disc with USG was first reported by Nebeith YB and Speculand B in 1991 with 3.5-MHz transducer [9]. Tissues are classified into broad categories depending on the ability of a tissue or structure to reflect or absorb sounds [10]. Bone tissue, represented by the head of the condyle and the articular eminence, is generally hypoechoic (low reflection of sound waves), and it appears black. However, the margin of the bone is hyperechoic (high reflection of sound waves), and it appears white in USG images. The surface of the joint capsule, as well as the surface of muscles, highly reflects the sound waves, thus generating a hyperechoic (white) line. The disc is visualized as a thin homogenous, hypo-to-isoechoic band. Empty space and water, like the superior and inferior joint spaces, are hypoechoic, and they appear black in USG images [11].

The advantage of high-resolution USG is that the articular disc can be viewed during the mouth opening in a dynamic manner. This study aims at utilizing ultrasound for assisting needle insertion for temporomandibular joint arthrocentesis and evaluating the treatment outcome.

Materials and methods

A randomized prospective study was conducted among 20 patients reporting to the out-patient department with an inclusion criteria of above 18 years and willing to give written informed consent, diagnosed with internal derangement having acute disc displacement without reduction of the temporomandibular joint. Patients with systemic illness or generalized joint disease were excluded from the study. Patients were divided in two groups (group A and group B), in which 10 patients were randomly assigned to each group. Group A patients underwent single-puncture arthrocentesis using modified double-lumen single-barrel needle, and group B patients underwent USG-guided single-puncture arthrocentesis. All the procedures were performed by a single qualified surgeon and a radiologist [12].

Patients of both groups were seated keeping Frankfort horizontal plane at 45° angle to the floor, with head turned to the unaffected side. Affected auricular region was prepared with 5% povidone-iodine and draped following strict aseptic measures, and the line was drawn from the tragus to the outer canthus with skin marking ink. The external auditory meatus on the affected side was blocked with a cotton plug.

Fig. 1 Single-puncture arthrocentesis using modified double-lumen single-barrel needle

Procedure for group A patients

Under aseptic precautions, auriculotemporal nerve block was given just anterior to the junction of the tragus and the ear lobe with 1.5 ml of local anesthetic (2% lignocaine with 1:2,00,000 adrenaline). Modified double-lumen single-barrel needle was inserted into the joint space 2 mm below and 10 mm ahead

Table 1 Standardized protocols for ultrasonography of temporomandibular joint [4]

Orientation of scanning is based on this standardized protocol to obtain cross-sections intersecting the antero-superior joint compartment in a sagittal-to-frontal plane.
1) Transducer is placed over TMJ, parallel to the long axis of mandibular ramus.
2) Transducer is tilted until the optimal visualization is obtained.
3) Disc is visualized as a thin homogenous, hypo-to-iso-echoic band lying adjacent to the inferior relation. The bony landmarks of the mandibular condyle and the articular eminence are visualized as hyperdense lines.
4) In a closed mouth, the position of the disc is defined as normal if the intermediate zone of the disc is located between the antero-superior aspect of the condyle and the posteroinferior aspect of the articular eminence. Disc with the intermediate zone located anterior to this position is considered displaced.
5) In an open mouth, the position of the disc is considered normal if the intermediate zone of the disc was located between the condyle and the articular eminence of the condyle.

Fig. 2 Ultrasound-guided single-puncture arthrocentesis using modified double-lumen single-barrel needle

from the mid-tragal end of Holmlund Hellsing's line (Fig. 1). From the entry port of the needle, the joint was irrigated with 100 ml of Ringer's lactate solution. Then, 100 mg hydrocortisone sodium succinate was injected following which the needle was withdrawn. Puncture point was covered with a sterile dressing for 24 h.

Procedure for group B patients

Group B patients were treated by single-puncture arthrocentesis with modified double-lumen single-barrel needle using ultrasound guided with a 12-MHz linear probe. With a 12-MHz linear array transducer on a LOGIQ P5 scanner (GE Medical systems, Wisconsin, USA), needle navigation through ultrasound was executed using standardized protocol described by Emshoff et al. [4] (Table 1). An ultrasonography probe was placed over the temporomandibular joint, perpendicular to the zygomatic arch and parallel to the ramus of the mandible, and tilted until the best imaging was achieved (Fig. 2).

Table 2 Number of attempts for needle manipulation

	Group A	Group B
Mean ± SD	2.20 ± 0.789	1.10 ± 0.316
t value	4.09	
p value	0.0007	

The disc was visualized as a thin homogeneous, hypo-to-isoechoic band (Fig. 3) lying adjacent to the inferior relation (overlying the mandibular condyle). The bony landmarks of the mandibular condyle and the articular eminence were visualized as hyperdense lines [1].

Auriculotemporal nerve block was given with 1.5 ml of local anesthetic (2% lignocaine with 1:2,00,000 adrenaline) under direct vision, and lavage was performed by modified double-lumen single-barrel needle with 100 ml of Ringer's lactate solution and following which 100 mg hydrocortisone sodium succinate was injected and the needle was withdrawn. Puncture point was covered with a sterile dressing for 24 h. The parameters evaluated were the number of attempts for needle manipulation for achieving the outflow; the duration of the operative procedure was measured from the time of inserting the double-lumen single-barrel needle into the joint up to the completion of lavage, which was assessed using a digital stopwatch by a blinded assistant and visual analog scale (VAS) score for pain to assess surgical discomfort.

Statistics

An inter-group analysis was assessed for individual parameter considering them as independent variable using mean and standard deviation (SD).

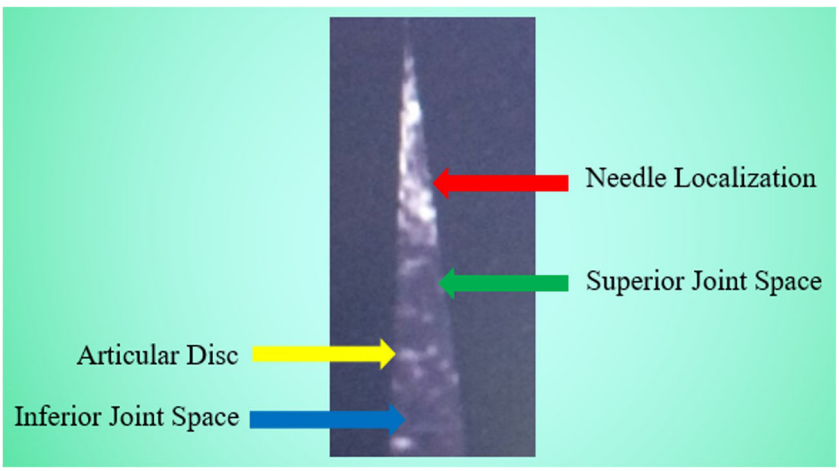

Fig. 3 Needle localization using ultrasonography (USG)

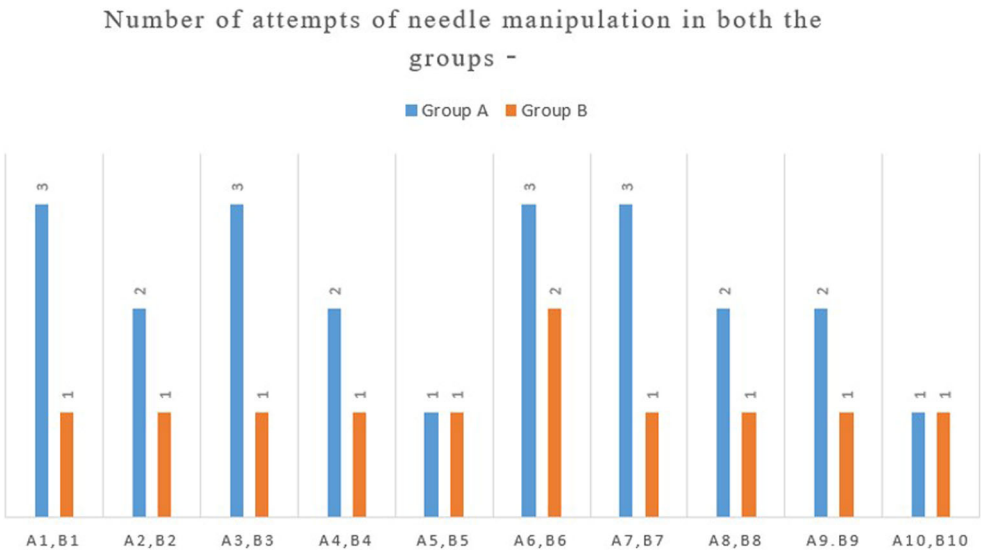

Fig. 4 Number of attempts for needle manipulation among the patients from both groups

Results

The study was conducted among 20 patients diagnosed with internal derangement of temporomandibular joint with acute closed lock jaw. Group A and B patients ($n = 10$ in each) did not differ significantly in age, clinical diagnosis, and Wilkes classification.

None of the patients among the study population developed any complications. The mean ± SD for number of attempts of needle manipulation for group A was 2.20 ± 0.789, and for group B, it was 1.10 ± 0.316 with a p value of 0.0007 (Table 2, Fig. 4). The mean ± SD of the operative procedural time for group A was 18.5 ± 3.171 min, and for group B, it was 13.1 ± 1.663 with a significant p value of 0.0002 (Table 3, Fig. 5). There was no significant difference in VAS scores for pain among the patients between the two groups (Table 4, Figs. 6 and 7).

Discussion

Bhargava et al. described that in a normal TMJ, the disc is positioned over the condylar head with the posterior band situated in the 12 o'clock (superior to the condyle) position and the intermediate zone situated in the 1 o'clock (superior-anterior to the condyle) position. On mouth opening, the disc–condyle complex translates in a forward direction. Although the condyle also rotates forward, the disc relatively rotates in a posterior direction over the condyle. In patients with internal derangement of TMJ, this normal joint dynamics is altered [1]. Common symptoms include clicking, pain, and tenderness in the pre-auricular area and masticatory muscles and limited mouth opening [13]. TMJ imaging is beneficial in determining the relationship between the hard and soft tissues of the joint and allows the assessment of the tissue integrity to be evaluated [13]. We had hypothesized that the USG-guided technique would reduce the number of attempts of needle manipulation and the duration of the operative procedure and VAS score for pain to assess surgical discomfort, offering an easier access to the joint space. However, we found that it reduced both the number of attempts of needle manipulation (mean ± SD for group A—2.20 ± 0.789 and for group B—1.10 ± 0.316, p value 0.0007) and operative procedural time (mean ± SD for group A was 18.5 ± 3.171 and for group B was 13.1 ± 1.663, p value 0.0002) significantly, but there was no significant difference in the VAS score. The operative procedural time was significantly less in the present study contrary to the evidence in the literature as the procedure of ultrasound and arthrocentesis was performed by an expert radiologist and maxillofacial surgeon specialized to perform TMJ surgeries. The subjective and objective outcomes were consistent in both the study groups without any complications. Complications of arthrocentesis are uncommon, though incidence of neurovascular injury, penetration of the middle cranial fossa, and damage to the joint have been reported [3].

Byahatti et al. conducted a clinical study on 100 patients with a 12-MHz transducer using dynamic USG to determine the value of dynamic high-resolution USG in the evaluation of

Table 3 Operative procedural time (in minutes)

	Group A	Group B
Mean ± SD	18.5 ± 3.171	13.1 ± 1.663
t value	4.77	
p value	0.0002	

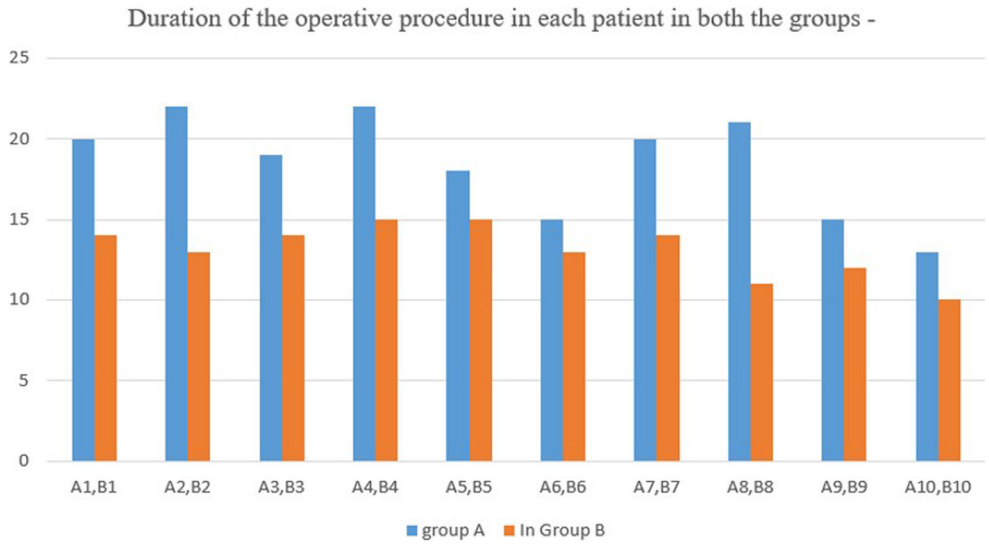

Fig. 5 Duration of the operative procedure in each patient in the groups

internal derangements of a temporomandibular joint in the open and closed mouth positions. He observed that sensitivity in the closed mouth position was found to be 80%, while in the open mouth position, it was 76% [14]. Kaya et al. assessed the diagnostic value of USG in the evaluation of anterior disc displacement. Sensitivity of USG was 91% in anterior disc displacement, 70% in anterior disc displacement with reduction, 50% in anterior disc displacement without reduction, and 53% in effusion [15]. Similarly, Manfredini et al. conducted a study on 69 patients and found that the diagnostic accuracy of ultrasound for depicting effusions was good. Ultrasound sensitivity was high for values which were below the cutoff value of 1.950, while specificity was high for values which were above 2.150 (TPR 71% and FPR 11.8%) [16]. The author stated that the sensitivity and specificity for ultrasound was high if the cut off value is below 1.950 mm and above 2.150 respectively.

Emshoff et al. determined the value of dynamic sonography in the evaluation of internal derangements of a temporomandibular joint during maximal mandibular range of motion [4]. They performed dynamic high-resolution sonography during the maximal range of motion which helped to detect 81 instances (93%) of internal derangement, 22 instances (82%) of disc displacement with reduction, and 50 instances (83%) of disc displacement without reduction. The accuracy of prospective interpretation of high-resolution sonograms of internal derangement, disc displacement with reduction, and disc displacement without reduction was 95%, 92%, and 90%, respectively, and it was concluded that dynamic sonography performed during maximal mandibular range of motion provides valuable information about disc displacement of the TMJ [4]. The accuracy in diagnosing internal derrangement, disk displacement with and without reduction based on interpretation in sonogram was 95%, 92% and 90% respectively.

Honda and Bjornland used cone-beam computed tomography (CBCT) to describe the optimum angle of insertion and distance from the puncture site to the upper joint space [17]. Matsumoto et al. assessed a CBCT image-guided puncture technique with a conventional technique for precision of entry of the needle, maximum inter-incisal opening achieved, and pain caused by manipulation by pumping. They found that the image-guided technique was significantly more accurate than the conventional technique [18]. It is true that the dose of radiation associated with CBCT is minimal, but its use is to define optimal access points which may nonetheless be controversial considering it involves ionizing radiations and its availability is limited [19]. Neither MRI nor USG requires exposure to ionizing radiation, so examinations may be

Table 4 Visual analog scale (VAS) score for assessment of pain

	Pre-operatively	On the 3rd day	On the 7th day	On the 15th day	After 1 month
Mean ± SD for group A	9.1 ± 0.738	5.7 ± 0.949	3.3 ± 0.949	1.7 ± 1.06	1.0 ± 0.774
Mean ± SD for group B	8.9 ± 0.738	5.8 ± 0.919	3.6 ± 0.843	1.6 ± 0.699	0.9 ± 0.738
t value	0.606	0.235	0.747	0.249	0.318
p value	0.55	0.81	0.46	0.81	0.75

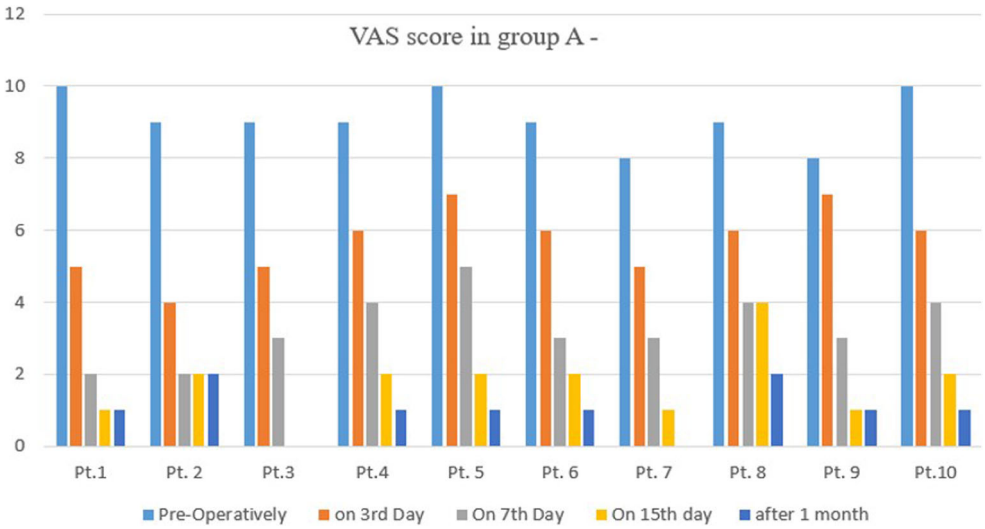

Fig. 6 Visual analog scale (VAS) scores among group A patients

repeated frequently when needed [20]. USG is relatively inexpensive compared with MRI and CBCT and yields real-time images that permit dynamic assessment. The devices are portable and mobile, which allows evaluation of both the joints with sufficient relevant imaging information [21].

One of the drawbacks can be the presence of artifacts in the USG as mentioned by Levorova et al. in his study. Artifacts can be present in any radiographs and not only in USG. The potential advantage of using an USG is if any artifacts are visualized, it can be corrected and the area of interest can be visualized immediately depending on the ability of the radiologist unlike other radiographic methods where the artifacts remain in the radiographic films. However, one disadvantage is the availability of skilled radiologist in all centers to visualize small joints like TMJ using an USG and practitioners who are less exposed to TMJ procedures may find it difficult to understand the USG of the TMJ region. Another point of interest is if the degenerative disease is as severe as mentioned by Levorova et al. to cause an artifact by masking the normal USG image of TMJ, arthrocentesis alone will not be the treatement of choice in such cases as we have included only patients who are diasgnosed under early stages of Wilkes classification in the present study [22].

Surgeons who are in the initial phase of practice or not specialized to perform TMJ procedure can find TMJ arthrocentesis tedious both using a conventional as well as USG-guided method. We justify that in the hands of an experienced surgeon, the procedural time can be decreased during an USG-guided TMJ arthrocentesis and the surgeons in the initial stage of practice can feel more confident doing an USG-guided arthrocentesis than an anatomic palpation-guided arthrocentesis as opined by Sibbitt et al. where he observed that surgeons new to joint arthrocentesis procedure were confident to perform USG-guided arthrocentesis [23].

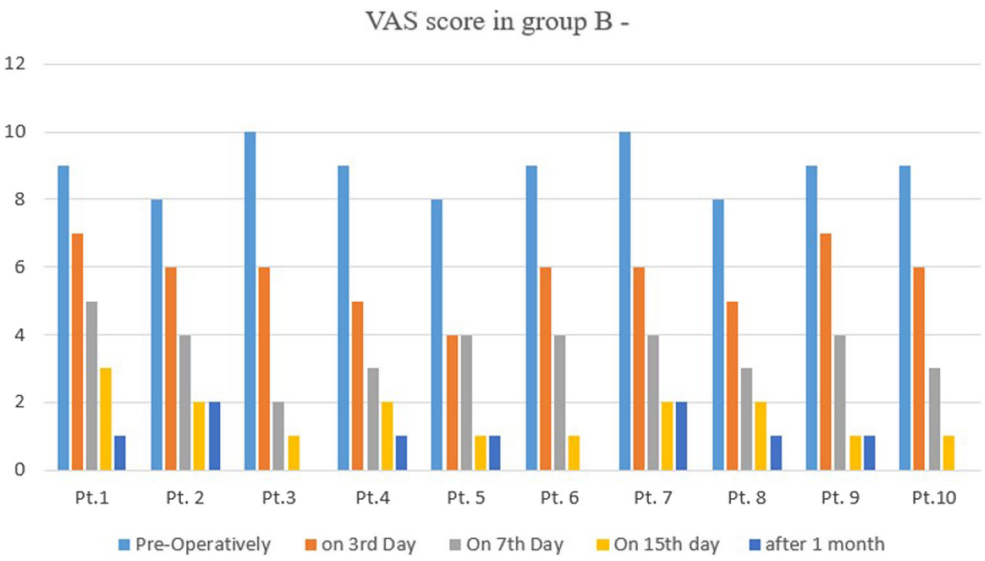

Fig. 7 Visual analog scale (VAS) scores among group B patients

Conclusion

USG is a nonionizing, noninvasive, fast, cost-effective, and painless diagnostic method which provides real-time and simultaneous imaging of the hard and soft tissue [21]. Studies have provided the use of ultrasonography as a promising diagnostic tool for the evaluation of oral and maxillofacial pathologies. Ultrasound-guided single-puncture arthrocentesis using a customized needle minimizes the number of attempts of needle manipulation and potential complication and provides easier access to the joint space. It is a promising method to perform joint lavage with minimal trauma and in a precise manner.

Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

Ethical approval Obtained. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from the patients involved in this study.

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