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American Journal of Oral and Maxillofacial Surgery

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Research Article

Khallaf and Sidebottom Guiding Stent for Temporomandibular Joint Arthrocentesis: A New Era for Joint Space Puncturing Techniques (Registered Technical Note)

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Abstract: Arthrocentesis is becoming the cornerstone of minimally-invasive surgical treatment for internal derangement of the temporomandibular joint (TMJID). Nitzan et al. first described arthrocentesis as the simplest form of surgery in the TMJID. Repeated arthrocentesis up to five times is 91% effective in treating patients with anterior disc displacement without reduction. It depends on lavage of the joint space through placement of two needles inside the superior joint space. The majority of surgeons use conventional puncturing technique (CPT), which is a blind technique for needle placement, in spite of its complications (extra-articular injection, multiple puncturing, facial nerve injury, intracranial penetration).Others use image guided puncturing techniques (CBCT,MSCT, MRI, or US) for superior joint space puncturing, which is proven to be a more accurate and precise technique with fewer complications. We fabricated a new customized guiding stent on a 3D soft and hard tissue model, printed out from MSCT, with adjusted depth and angulation for superior joint space puncturing. The puncturing using this new stent is easy and does not subject patients to imaging each time, as the confirmation of the needle positioning has already been done by the accurate measurements on MSCT. In addition, the procedure no longer requires general anesthesia or deep sedation. Clinically significant differences were noted between the use of IGPT and the present guiding stent, especially on the level of procedural time. These observations confirmed that the use of this stent was a predictable and highly efficient new approach for superior joint space puncturing.

Keywords: TMJ arthrocentesis; TMJ internal derangement; 3D printed models

Received: April 26, 2019; Accepted: May 31, 2019; Published: July 25, 2019

Competing Interests: The authors have declared that no competing interests exist.

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Introduction

Arthrocentesis is the simplest form of surgery in the TMJ, aiming to release the articular disc and to remove adhesions between the disc surface and the mandibular fossa by means of hydraulic pressure from irrigation of the upper chamber of the TMJ. The original technique,first described by Nitzan et al. [1], consists of lavage of the upper joint space of the TMJ by placement of two needles inside the joint space with no direct vision, aiming primarily to remove necrotic tissue, blood, and pain mediators from the joint. Arthrocentesis has low morbidity, few risks, and low cost compared to other TMJ surgeries. Few clinical studies have compared CPT with IGPT for superior joint space puncturing [2].

In the CPT method, positions of the mandibular fossa and condylar head were preoperatively confirmed by palpation or tactile sense as anatomical indicator points. A point was made 10 mm anterior along and 2 mm below a line drawn between the midpoint of the tragus of the ear and the lateral canthus of the eye, The puncture point was indicated on the skin by tracing the outline with a marker [3]. The superior joint cavity was therefore punctured in the fossa or along the posterior slope of the tubercle. The percentage of re-correcting the needle position may exceed 18% for experienced operators and 45% for those who are inexperienced [4,5].

In the IGPT method, to permit safe and accurate insertion of the puncture needle, an outline of the condyle and fossa was elicited on palpation of the TMJ area and drawn using a medical marker on the skin. In addition, referencelines (Frankfort horizontal [F-H] plane) and axial planes passing through the top of the condyle were drawn on the skin. A small metal ball (1.5 mm diameter) was placed on the skin surface covering the top of condyle using medical adhesive (Aron alpha A; Daiichi-Sankyo, Tokyo, Japan). The patient was positioned in the F-H plane, parallel to the floor, and CBCT was then performed. Images were not rotated for preoperative image evaluation.

First, the point to be reached by the needle tip was set according to the posterior slope of the articular tubercle on the CBCT monitor. Based on this set point and the 3-dimensional features of the individual morphology of the mandibular fossa, the insertion point of the needle on the skin was decided. Next, puncture angles with respect to the reference plane (axial plane) were measured using the image tool in I-view 3D software (Morita Manufacturing). In addition, the distance between the insertion point and end point, and the distance between the metal ball and insertion point (vertical and horizontal distances) were measured using the same image tools.

The measured coordinate point of the insertion with respect to the center of the metal ball was drawn using a marker,and a puncture with the needle was made along the determined angle. The depth of puncture was reproduced using a rubber stopper (used for endodontic therapy). Others use US, MRI, and fluoroscopy. However, the problem of instability of the needles (especially on the level of depth) during the injection is still present even with developing of IGPT [6-9].

Clinical use of arthrocentesis in the TMJ is a new procedure among other possibilities of treating joint dysfunction, and it is now widely used. Therefore, there is a need for studies on the technique, success rate, and complications of this procedure.

Material and methods

Eight patients with TMJ internal derangement from Al-Azhar University Hospitals were included in this study. The Ethical Committee of the Faculty of Oral & Dental Medicine has approved the protocol for research. All patients underwent multi-slice computed tomography (MSCT).The obtained data was imported to Mimics software (in Queens Medical Center, Nottingham University Hospital, NHS Trust) and the two points of interest digitally placed in the upper joint space. We then edited the soft tissue mask using the 3D option (transparent form) to cover the bone and the two point extensions, transferred to the superficial skin with adjusted angulation.(Fig.1) Then the depth of penetration was measured and recorded for each needle.

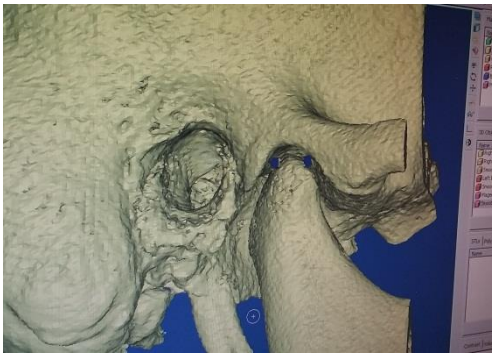

Fig. 1A Twopoints were placedinupper joint space

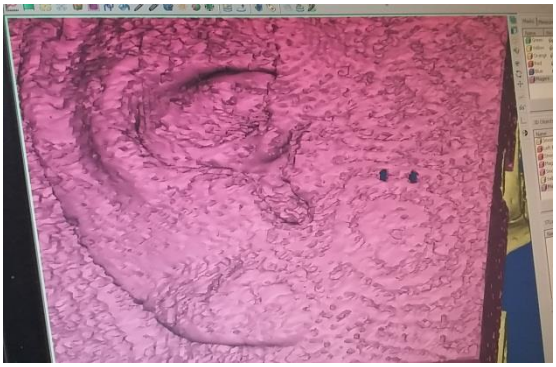

Fig. 1B Points transferred to overlying soft tissue(skin)

Fig. 2A Printed ear/surrounding soft tissue

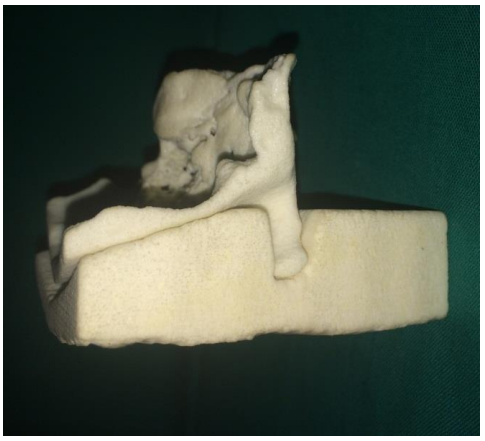

Fig. 2B Coordination between soft and hard tissue printed models

Both hard and soft tissue of TMJ, as well as thesoft tissue overlying the joint externally (with the two marked holes) and the ear, were printed out using a three-dimensional printer (Z-CORP, USA). The material used for printing was PEEK and Silicon. The obtained models of the soft and hard tissue were correlated to each other to make sure that they were properly coordinated (Fig.2) and that there were no errors during printing. The model used to fabricate the guiding (acrylic) stent had an extension

inside the external ear for more stabilization, and two holes were made to match the holes on the model. The metal sleeves were used to adjust and fix the premeasured depth of insertion, and they were fixed to the stent in the two holes (Fig.3).The stent was checked on the model, then on the patient for any error. (Fig.4A&B). Then it was sterilized using GAMMA Rays, and the area of interest was disinfected using butadiene foam. Under topical anesthesia (EMLA), the stent was placed in proper position, the needles were inserted through the metal sleeves, and the infusion pump was connected to the entrance point. Needle patency and positioning of the needles was confirmed by the outflow of Ringer solution from the exit needle (Fig.5).

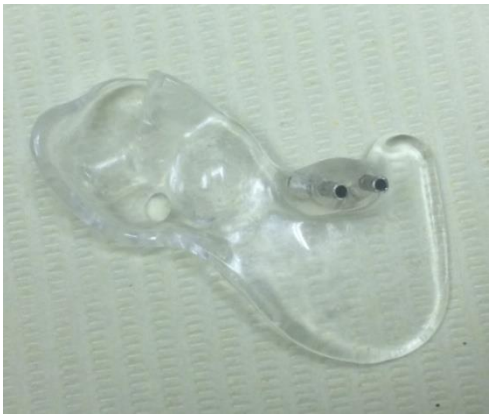

Fig. 3 The fabricated stent (Khallaf & Sidebottom stent)

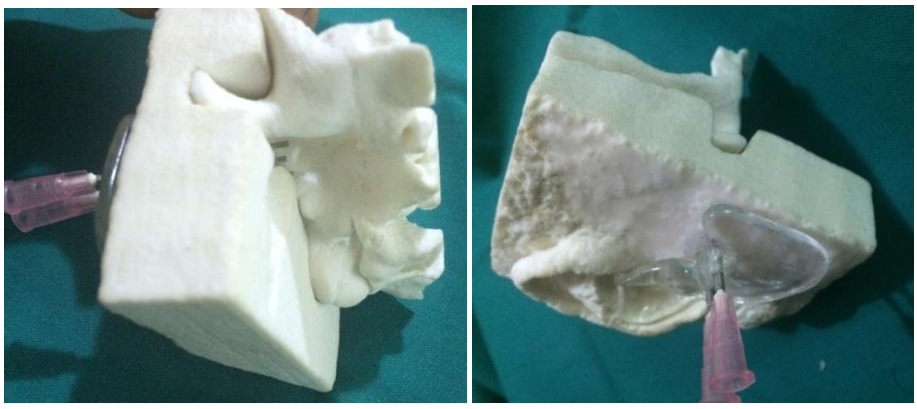

Fig. 4A Stent-checking on the printed model.

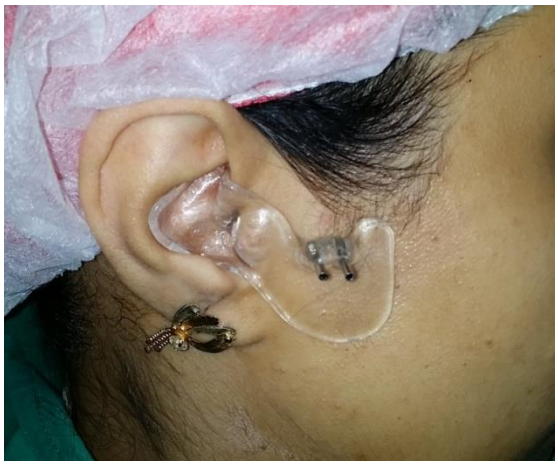

Fig. 4B Stent-checking on the patient.

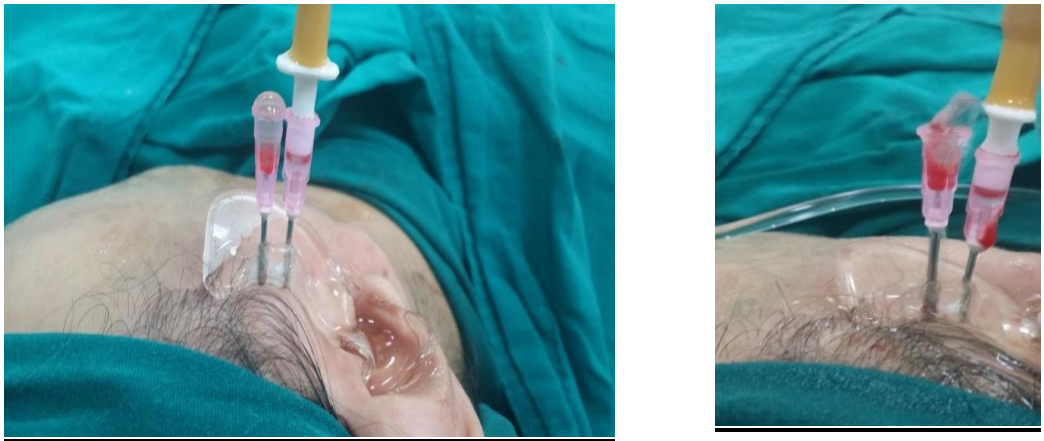

Fig. 5 The stent is working efficiently on the patient during arthrocentesis.

Results

Objective findings

Table 1 summarizes and compares objective pre- and postoperative findings. All patients had improved mouth opening following arthrocentesisusing Khallaf& Sidebottom stent, with no complications or post-operative pain related to the site of the procedures, other than mild discomfort for a maximum of three days. Patients were surprised to finish the procedure using topical anesthesia within a few minutes. Preoperative mouth opening was 31.83mm ±8.10mm and postoperative mouth opening was 36.50mm ±6.89mm. Lateral movements and protrusion were unaltered.(Table 1).Three patients presented with joint noises on the preoperative clinical exam. At the end of treatment, two no longer had joint noises and one had a reduction in joint clicks.

Table 1 Measurement of the pre- and postoperative mandibular movement amplitude.

Variable	*Minimum*	*Maximum*	*Average*	*Mean*	*S.D*(1)
Maximum preop. mouth opening	*20*	*42*	*31.38*	*30.50*	*8.10*
Maximum postop. mouth opening	*29*	*46*	*36.50*	*36*	*6.89*
Preop. lateral movement to the right	*3*	*8*	*6*	*6.50*	*1.78*
Postop. lateral movement to the right	*5*	*12*	*8.50*	*9*	*2.58*
Preop. lateral movement to the left	*4*	*9*	*6.58*	*6.25*	*1.74*
Postop. lateral movement to the left	*5*	*10*	*7.16*	*7*	*2.13*
Preop. protrusion movement	*3*	*10*	*7.16*	*8*	*2.71*
Postop. protrusion movement	*3*	*8*	*5*	*5*	*1.67*

(1)Standard deviation

Table 2 Pre and postoperative pain scores on VAS Analog

Variable	*Minimum*	*Maximum*	*Average*	*Mean*	*S.D*
Preop. Pain Visual Analog Scale	*5*	*10*	*7*	*6.50*	*1.78*
Postop. Pain Visual Analog Scale	*3*	*6*	*4.33*	*4*	*1.03*

Subjective finding:

All patients had no preoperative pain but had mild discomfort. Preoperative pain visual analog scale scores averaged 7 ±1.78. On follow-up the pain score fell to an average 4.33 ±1.03. All patients reported an improved general clinical status and a reduction of internal derangement symptoms. (Table 2). Maximum mouth opening, right lateral movements, and the pain visual analog scale were statistically significant ($p < 0.05$) based on the Wilcoxon test. (Table 3).

Table 3 Statistical analysis of objective and subjective findings.

	Maximum postoperative mouth opening	Pain Visual Analog Scale Postop	Right Lateral Movement Postop	Right Lateral Movement Postop.	Mandibular protrusion movement Postop.
	Maximum preop. mouth opening	Pain Visual Analog Scale – Preop	Right Lateral Movement – Preop	Right Lateral Movement - Preop.	Mandibular protrusion - Preop.
Z	-2,023 [a]	-2,226b	-2,003 [a]	7,36 [a]	-1,633b
Asymp. Sig. (2-tailed)	.043*	.026*	.045*	.461	.102

a. Based on negative ranks
b. Based on positive ranks
c. Wilcoxon Signed Ranks Test

The use of this stent showed severe reduction in time needed for accurate needle positioning into the upper joint space and for the procedure as whole.Reduction in postoperative pain (especially for unexperienced operators) was seen, with evidence of zero risk of complications (especially extra-articular injections).

Discussion

Lavage of the upper joint space reduces pain by removing inflammation mediators from the joint (Quinn, Bazan, 1990) and increases mandibular mobility by removing intra-articular adhesions (Spallacia et al., 2000). It eliminates the negative pressure within the joint, recovering disc and fossa space (Nitzan et al., 1991). Disc mobility is improved, which reduces the mechanical obstruction caused by the anterior position of the disc (Moses et al., 1989) [11].

Arthrocentesis has an intermediate place between the medical and the surgical forms of treatment (Salazar et al., 2004). Ease, lower cost of materials, and excellent published results so far include this technique in the international protocol for the treatment of TMJ internal derangement. Many authors suggested repeating the procedure up to five times,as it could be effective with different degrees after five administrations of lavage and injection [10]. The technique appears to be simple but may have a number of complications and difficulties, especially for the beginners. To date, there are no longitudinal studies to evaluate the accuracy of needle positioning. However,the majority of surgeons depend on the cantho-tragal line (Holmlund-Hellsing line) to detect the two points for needle insertion, although it is not a reliable technique for superior joint space puncturing. Others used image-guided puncturing techniques such as US, MRI, and CBCT. The problem with its use lies in that the patients must be subjected to another dose each time in order to repeat the arthrocentesis.

In our study we used a custom-made guiding stent to simplify and shorten the time of the procedure with no error in puncturing technique. No previous studies used similar guidance or even the idea itself. By using this stent we gained similar results on the level of pain reduction and maximum pain-free mouth opening, as well as lateral excursion of Vasconcelos et al [12] study in 2006, however the follow up period in our study was three months only. Moreover, these results in comparison to published studies named (Frost et al., 1999; Dimitroulis, 1995; Nitzan et al., 1997; Carvajal, Laskin, 2000) [13-16]. Better results for postoperative pain following arthrocentesis were obtained in this study than among the previous studies. No wasted time was observed either to correct the needle angulation or depth of penetration by using this stent, which makes it superior in time-saving for both the operator and the patient.

Conclusion

The use of the Khallaf & Sidebottom guiding stent was an effective, safe and reliable tool for superior joint space puncturing instead of blind puncturing and/or IGPT, with better results in postoperative pain and time-saving compared to previous studies.

Acknowledgements

I would like to express my deepest appreciation to Prof. Dr. El Saeed Abdelatif, Prof. Dr. Ahmed Adawy, Dr. Kate O'Donnell , Dr. Mohamed Elmasry and Prof.Dr.Hatem Alahmady for their supportive opinions and help.

Conflicts of interest

The authors affirmed that there are not any conflicts of interest.

Publishing Note

This technical note is the first clinically registered note using this stent design and technology for TMJ puncturing techniques under research registry unique identifying number in Dec., 28, 2016.

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