An image-guided technique for puncture of the superior temporomandibular joint cavity: Clinical comparison with the conventional puncture technique

Kunihito Matsumoto, DDS, PhD,^a Tore Bjørnland, DDS, PhD,^b Yukiko Kai, DDS,^c Masahiko Honda, DDS, PhD,^d Yoshiyuki Yonehara, MD, PhD,^e and Kazuya Honda, DDS, PhD,^f Tokyo, Japan, Oslo, Norway, and Malmö, Sweden
NIHON UNIVERSITY, UNIVERSITY OF OSLO, AND MALMÖ UNIVERSITY

Objective. The objective of this study was to compare an image-guided puncture technique (IGPT) with conventional puncture technique (CPT) with respect to accuracy of needle entry, maximal mouth opening, and pain in pumping manipulation treatment of internal derangement of the temporomandibular joint (TMJ).

Study design. The subjects comprised 178 patients with internal derangement of the TMJ with closed lock. Treatment was provided using CPT in 102 cases and IGPT in 76 cases. Three variables, number of repunctures, maximal mouth opening distance, and pain threshold according to a visual analogue scale, were measured and compared between IGPT and CPT groups.

Results. Access to the superior joint cavity was achieved without correcting the puncture point in 97% of patients who underwent IGPT and 82% of patients in the CPT group. Significant differences were seen in 1-week maximal mouth opening and pain threshold between IGPT and CPT groups ($P < .05$ each) and resetting of the puncture point was significantly less frequent using IGPT compared with CPT ($P < .05$).

Conclusions. IGPT is effective for pain mitigation and improves mouth opening during the early postoperative period after pumping manipulation treatment. (*Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2011;xx:xxx)

Many modalities have been established for diagnostic imaging of the temporomandibular joint (TMJ), including plain radiography, arthrography, magnetic resonance imaging (MRI), computed tomography (CT),

cone-beam CT (CBCT), and arthroscopy.¹⁻⁷ Since the emergence of MRI, arthrography and arthroscopy of the TMJ have been performed less frequently in patients with TMJ disorders because of the invasiveness and technical difficulty of these procedures.⁷ Puncturing the TMJ cavity is a basic technique used for diagnosis and treatment of joint cavity lesions in TMJ disorders, and is frequently used clinically. Puncturing the TMJ cavity permits contrast studies, arthroscopy, pumping manipulation, arthrocentesis, drug injection, and collection of fluids from the joint cavity⁸⁻¹³; however, puncturing the TMJ cavity may cause complications, such as facial nerve damage, penetration of the middle cranial fossa, or irreversible changes to the TMJ itself.¹⁴⁻¹⁷ In disorders such as severe temporomandibular osteoarthritis and synovial chondromatosis, TMJ disk examination, arthrocentesis, arthroscopic surgery, and other techniques are useful and significantly influence the clinical course.^{8-12,16-18} Safer, more reliable, and easier puncture of the TMJ cavity would thus improve quality of life for the patients. The effectiveness of image-supported surgical procedures has often been reported in the medical field, and safer methods have undergone continued development,^{19,20} but few such reports have been presented in dentistry.²¹⁻²³ We have already reported the effectiveness of the image-guided puncture technique (IGPT),²¹ but no clinical

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^aAssistant Professor, Department of Oral and Maxillofacial Radiology, Nihon University, School of Dentistry, Tokyo, Japan.

^bProfessor, Department of Oral Surgery and Oral Medicine, Faculty of Dentistry, University of Oslo, Norway; Professor and Chairman, Department of Oral and Maxillofacial Surgery, Faculty of Odontology, Malmö University, Sweden.

^cPostgraduate Student, Department of Oral and Maxillofacial Radiology, Nihon University, School of Dentistry, Tokyo, Japan.

^dLecturer, 2nd Division, Department of Oral and Maxillofacial Surgery, Nihon University, School of Dentistry, Tokyo, Japan.

^eProfessor and Chairman, 2nd Division, Department of Oral and Maxillofacial Surgery, Nihon University, School of Dentistry, Tokyo, Japan.

^fProfessor and Chairman, Department of Oral and Maxillofacial Radiology, Nihon University, School of Dentistry, Tokyo, Japan.

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Table I. Distribution of patients (n = 178) by sex and puncture technique

	Male	Female	Total
IGPT	12	62	76
CPT	23	79	102

CPT, conventional puncture technique; IGPT, image-guided puncture technique.

comparisons of IGPT with the conventional puncture technique (CPT) have yet been described.

The purpose of this study was to compare IGPT with CPT with respect to accuracy of needle entry, maximal mouth opening, and pain in pumping manipulation treatment of internal derangement of the TMJ.

MATERIAL AND METHODS

We studied 178 subjects with internal derangement of the TMJ and closed lock, based on both clinical and MRI examinations, using either the CPT technique (n = 102; 23 men, 79 women; mean age, 36 years; range, 16-62 years) or IGPT (n = 76; 12 men, 64 women; mean age, 38 years; range, 18-58 years) for pumping manipulation therapy (Table I). Patients were randomly divided into either group without consideration of disease severity. Anatomical landmarks were used in CPT, and CBCT (3DX multi-image micro CT; Morita Manufacturing, Kyoto, Japan) was used in IGPT to safely puncture the superior TMJ cavity. All the procedures were performed by the same oral radiologist (K.H.) who was experienced in TMJ puncture.

The use of patients for this study was reviewed and approved by the Bioethics Committee at Nihon University School of Dentistry, Japan. All patients provided written informed consent to participate in this study.

CPT Method

In the CPT method, positions of the mandibular fossa and head were preoperatively confirmed by palpation as anatomical indicator points, based on a point 10 mm from the antilobium on the line between the midpoint of the antilobium and the lateral angle of the eye. The puncture point was indicated on the skin by tracing the outline with a marker. The superior joint cavity was therefore punctured in the fossa or along the posterior slope of the tubercle. A wide area of skin around the preauricular region was disinfected using isodine and 8% hypoalcohol. Infiltration anesthesia was administered by subcutaneous injection of 2% xylocaine (AstraZeneca, Osaka, Japan), using a 26-G needle. Arthrography was performed from the superior joint cavity under fluoroscopy, using CT with a

21-G needle. The contrast medium was nonionic isovist (Bayer Schering Pharma, Osaka, Japan).

IGPT Method

In the IGPT method,²¹ to permit safe 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, reference lines (Frankfort horizontal [F-H] plane) and axial planes passing through the top of the condyle were drawn on the skin (Fig. 1, A). A small metal ball (diameter, 1.5 mm) was placed on the skin surface covering the top of condyle using medical adhesive (Aron alpha A; Daiichi-Sankyo, Tokyo, Japan) (Fig. 1, B). 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 (Fig. 2). 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) (Fig. 3). In addition, the distance between the insertion point and end point, and the distance between the metal ball and insertion point (vertical and horizontal distance) were measured using the same image tool (Fig. 3).

The measured coordinate point of the insertion point with respect to the center of the metal ball was drawn using a marker (Fig. 1, B). A wide area of skin around the preauricular region was disinfected using isodine and 8% hypoalcohol. Infiltration anesthesia was administered by subcutaneous injection of 2% xylocaine using a 26-G needle.

To reproduce the measured angle and depth of puncture needle (21-G needle), we used a plastic semicircular protractor that had been sterilized using ethylene oxide gas. First, the protractor was set to the reference plane (axial plane). The puncture needle was set and adjusted according to the angle measured with respect to the axial plane (Fig. 1, C), then a puncture with the needle was made along the determined angle. The depth of puncture was reproduced using a rubber stopper for endodontic therapy (GC, Tokyo, Japan) (Fig. 1, D). The depth of puncture is often changed and requires appropriate coordination, owing to bulging of the skin surface caused by infiltration anesthetic or indentation of the skin produced by astriction.

When the needle puncture had proceeded to the measured depth, pumping action of the syringe was performed, irrespective of whether the needle tip had

Fig. 1. IGPT method. **A**, The basic shapes of the condyle, fossa, and reference lines are drawn on the skin. **B**, A small metal ball is bonded to the skin surface. Arrowhead shows the insertion point as set by preoperative CBCT evaluation. **C**, The puncture needle is set and adjusted using a sterile plastic semicircular protractor according to the angle measured with respect to the axial plane. **D**, The depth of puncture is reproduced using a rubber stopper for endodontic therapy.

reached the joint cavity. If back-flow of xylocaine was not confirmed, the depth was adjusted and rechecked using the same manipulation. After confirming that the joint cavity had been reached, arthrography was performed from the superior joint cavity under fluoroscopy, using CBCT. Nonionic isovist was used as the contrast medium. **Figs. 3 and 4** show CBCT arthrography and images obtained using the double-contrast method for a patient treated using IGPT. **Figs. 2 to 4** show images of the same patient treated using the IGPT method.

Pumping manipulation procedure

In all subjects during both puncture methods, pumping manipulation treatments were performed after confirming the flow of contrast media into the superior joint cavity. The joint cavity was alternately washed with xylocaine and saline. Finally, 1.0 mL of sodium hyaluronate was injected into the cavity.

Explanation of variables

The effectiveness of IGPT was assessed by measuring 3 variables: (1) the number of repunctures, i.e., whether access to the superior joint cavity could be achieved without correcting the puncture points; (2) maximal mouth-opening, measured as the distance between the central incisors (this variable was defined

according to the opening distance at which the patient could no longer stand the pain); and (3) the pain threshold, determined by self-assessment using a visual analogue scale (VAS), with responses ranging from 0 mm (no pain) to 100 mm (the most intense pain imaginable).

Statistical analysis

Statistical analysis of changes in the puncture point between IGPT and CPT was performed with Mann-Whitney *U* test using SPSS for Windows version 11.0 (SPSS Japan, Tokyo, Japan). The unpaired 2-group *t* test was used to compare maximal mouth opening and pain thresholds during IGPT and CPT, using SPSS for Windows. Values of *P* less than .05 were considered statistically significant.

RESULTS

Access to the superior joint cavity was achieved without correcting the puncture points in 97% of patients who underwent IGPT and 82% of patients who underwent CPT. A significant difference in the frequency of changing puncture points was seen between IGPT and CPT ($P < .05$) (**Table II**).

In the IGPT group, mean maximal mouth opening was 24 mm before treatment and 40 mm at 1 week after treatment. Maximal mouth opening improved signifi-

Fig. 2. Preoperative CBCT evaluation. Patients were positioned in the F-H plane, parallel to the floor. Images were not rotated during evaluation. Arrowhead shows the point reached by the needle tip according to the posterior slope of the articular tubercle. A, Axial image; B, oblique coronal image; C, oblique sagittal image.

cantly to 44 mm after 3-months of observation time and 45 mm after 1-year of observation time. In the CPT group, mean maximal mouth opening was 26 mm before treatment and 33 mm 1 week after treatment. Maximal mouth opening in this group improved significantly to 40 mm after 3 months and 43 mm after 1 year. A significant difference in 1-week maximal mouth opening was apparent between IGPT and CPT ($P < .05$) (Table III).

In the IGPT group, mean VAS rating was 54 mm before treatment and 25 mm at 1 week after treatment. Pain rating improved significantly to 8 mm after 3-months and 6 mm after 1-year follow-up. In the CPT group, mean VAS rating was 52 mm before treatment and 35 mm at 1 week after treatment. Pain rating in this group improved significantly to 10 mm after 3-month follow-up and 4 mm after 1-year follow-up. A significant difference in 1-week VAS was apparent between

IGPT and CPT ($P < .05$) (Table IV).

DISCUSSION

Puncturing the TMJ cavity is the most basic skill in TMJ surgery. Surgical treatment of the TMJ should be the choice when conservative treatments have yielded only minimal effectiveness. In any case, the invasiveness of the surgical procedure needs to be reduced and less invasive treatments for patients need to be developed; pumping manipulation is one of the least invasive procedures for TMJ treatments. Accuracy of the puncture for pumping manipulation may influence the therapeutic outcomes and prognosis, because the pumping manipulation procedure itself is very simple. The present study compared 2 puncture techniques during pumping manipulation treatment in patients with TMJ disorders.

In 2 (3%) of our 76 cases using IGPT and 18 (18%) of 102 cases using CPT, puncture needles did not reach the superior TMJ cavity on the first attempt. Statistical analysis in the present study showed that IGPT was

Fig. 3. Setting insertion point, vertical angle, and depth of puncture needle using CBCT image. Based on the set point and the 3-dimensional features of individual morphology of the mandibular fossa, the insertion point of the needle on the skin is decided in the same slice image (arrowhead). The distance between the metal ball and insertion point (a), the angle of puncture (b), and the depth of the puncture were measured using image analysis software. **A**, Axial image; **B**, oblique coronal image; **C**, oblique sagittal image.

more accurate than CPT for puncture point settings. This supports the notion that IGPT using CBCT is suitable for image-guided puncture of the TMJ with minimal invasiveness to the patient. Of note was that the 2 cases in which IGPT failed were attributable to incorrect angle measurement following movement by the patient. Ancillary equipment to hold the head or needle in place should thus be developed to avoid such problems in the future and to ensure a correct puncture angle. Understanding of the morphologic features of the individual patient, including the shape of bone components as well as the length and angle between puncture points of the skin and cavity, will contribute to accurate needle insertion.

Using CT, ultrasonography and MRI, image-guided puncture has been reported in medical fields, particularly for needle biopsies,^{19,20} and the efficacy of image-guided puncture for deep and difficult sites has been

studied. In the dental field, our previous report and a few others regarding image-guided TMJ puncture have been published.²¹⁻²³ We have reported the effectiveness of image-guided puncture of the TMJ cavity using CBCT,²¹ whereas Fritz et al.²³ reported a 100% puncture success rate using real-time MRI planning. Yeung et al.²² introduced an automatic puncture technique for the superior and inferior joint cavities of the TMJ, assisted by 3-dimensional MRI using a special navigation system; clinical outcomes of that method have yet to be shown.

As CBCT cannot visualize soft tissue, including disk and retrodiscal tissue, MRI-assisted methods may be more suitable for planning TMJ puncture. However, almost all patients requiring TMJ surgical treatments have been diagnosed by prior MRI examinations for the position, form, and size of disk and joint components. Only arthrography or invasive arthroscopy can reveal

Fig. 4. Arthrography and double contrast method on CBCT images. Needle puncture is performed according to the preoperative plan. CBCT provides clear high-resolution arthrographic images of the TMJ and contributes to sensitive diagnosis of patients. **A**, Oblique coronal image from arthrography; **B**, oblique sagittal image from arthrography; **C**, oblique coronal image from double-contrast arthrography; **D**, oblique sagittal image from double-contrast arthrography.

Table II. Number of resettings of the puncture point in 178 TMJs

	Change of puncture point		
	0	1	2
IGPT (n = 76)	74	2	0
CPT (n = 102)	84	15	3

Frequency of change of puncture points differed significantly between IGPT and CPT ($P < .05$).

CPT, conventional puncture technique; IGPT, image-guided puncture technique; TMJ, temporomandibular joint.

the presence of perforation and adhesion of the disk. We thus believe that puncture planning and image evaluation by CBCT is adequate, safe, and valuable.

This clinical trial has demonstrated that pumping manipulation using IGPT is effective for pain mitigation and improvement of mouth opening during the

early stages of treatment. Early pain relief in IGPT cases may be assisted by short treatment time and accurate puncture, and early pain relief should therefore contribute to early improvement of mouth opening. In addition, sodium hyaluronate may also contribute to improvement of symptoms. Sodium hyaluronate has been widely used for patients with various joint disorders.^{24,25} However, injection of sodium hyaluronate into the TMJ cavity as well as drug administration and physiotherapy after pumping manipulation treatment may have biased the study results.

To the best of our knowledge, no previous reports have compared postoperative pain and puncture methods using TMJ puncture. Our results suggest the presence of a strong correlation between postoperative pain and TMJ puncture, and that TMJ puncture itself can cause evanescent synovial and soft tissue inflammation, although such inflammation may improve after 1 week. On the other hand, no significant difference was appar-

Table III. Change in mean maximal mouth opening over time

	Mean maximal mouth opening, mm			
	Before TMJ injection	1 wk after TMJ injection	3 mo after TMJ injection	1 y after TMJ injection
IGPT	24 ± 5.2	40 ± 6.1*	43 ± 5.5	44 ± 5.5
CPT	26 ± 5.0	33 ± 5.9*	40 ± 5.6	42 ± 5.9

Values are given as mean ± standard deviation.

CPT, conventional puncture technique; IGPT, image-guided puncture technique; TMJ, temporomandibular joint.

*A significant difference was identified in 1-week maximal mouth opening between IGPT and CPT ($P < .05$).

Table IV. Changes in mean pain evaluation over time using VAS (0-100)

	Before TMJ Injection	1 wk after TMJ injection	3 mo after TMJ injection	1 y after TMJ injection
IGPT	54 ± 9.0	25 ± 12.2*	8 ± 10.4	6 ± 7.7
CPT	52 ± 9.6	35 ± 13.5*	10 ± 12.2	4 ± 6.5

Values are given as mean ± standard deviation.

CPT, conventional puncture technique; IGPT, image-guided puncture technique; TMJ, temporomandibular joint; VAS, visual analog scale.

*A significant difference was observed in 1-week VAS between IGPT and CPT ($P < .05$).

ent between IGPT and CPT groups in terms of pain or mouth opening after the 1-month follow-up.

In conclusion, the present investigation has shown that IGPT may be the most reliable method for TMJ puncture. IGPT is effective in pain mitigation and improves mouth opening after pumping manipulation treatment in patients with internal derangement. The present study indicates that IGPT using CBCT is a safe procedure for treating internal derangement of the TMJ. Methods for automating, standardizing, and obtaining reproducible results for puncturing the joint cavity need to be improved in future studies.

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Reprint requests:

Kunihito Matsumoto, DDS, PhD
Department of Oral and Maxillofacial Radiology
Nihon University
School of Dentistry
1-8-13 Kanda-Surugadai, Chiyoda-ku
Tokyo 101-8310, Japan
matsumoto@dent.nihon-u.ac.jp