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ORIGINAL ARTICLE

Signs and symptoms after temporomandibular joint washing and cannula placement assessed by cone beam computerized tomography

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Abstract

Objective. Analyses of temporomandibular joint synovial fluid using the hydroxocobalamin push–pull technique are increasingly used. However, objective complications and subjective experiences from this procedure have not been described. Firstly, this study aimed to describe discomfort and potential side-effects of this method with special emphasis on symptoms related to the arthrocentesis to be used for future patient information and Ethical Committee applications. Secondly, this study aimed to evaluate the use of cone beam computed tomography (CBCT) as control of intra-capsular cannula placement. ***Methods.*** Twenty healthy, young adult volunteers were included. Extensive objective and subjective questionnaires were completed before and 14 days after the synovial fluid sampling. With the cannula inside the joints a CBCT was done to investigate if this procedure can be used to verify intra-capsular cannula position. ***Results.*** The subjective findings: Most subjects did experience mild pain or discomfort post-operatively. In 12 of 20 subjects symptoms had resolved after 2 days and no subjects had symptoms for more than a week. The longer lasting symptoms were mainly transient joint sounds on mandibular movement. Objective findings: 14 days after the sampling mandibular protrusion had improved 1 mm, but all other objective measures were equal compared to baseline. CBCT showed a large variation in cannula position and no conclusions could be drawn from this. ***Conclusion.*** The hydroxocobalamin push–pull synovial fluid sampling may cause minor, transient symptoms. CBCT does not seem to provide any clinical benefits concerning the correct cannula position in relation to the upper joint compartment and disc.

Key Words: *arthrocentesis, temporomandibular joint, symptoms, signs, cone beam computerized tomography*

Introduction

In research related to temporomandibular joint (TMJ) pathology as well as diagnostics and treatment of related conditions, invasive methods like arthroscopy or arthrocentesis are options to provide biopsies or synovial fluid (SF) samples for detailed examination. SF sampling is one method to retrieve molecular-level information [1]. The application of a minimally invasive method like SF sampling should cause considerations regarding risks of the method used versus the benefit of the findings that the sampling may provide. Retrieving TMJ SF is difficult due to the low SF volume and different methods for retrieving SF have been proposed [2,3]. The hydroxocobalamin push–pull method developed and described by Alstergren et al. [2] enables quantification of the SF volume retrieved after joint washing by measuring the dilution of the joint aspirate by spectrophotometry [4]. This enables calculation of true TMJ SF concentrations of the analyzed mediators. The hydroxocobalamin push–pull technique differs from previously described measures where the aspirated SF cytokine levels were correlated to the total protein content [3]. However, the cytokine/total protein content ratio is changed in inflammatory conditions [5], whereas the hydroxocobalamin push–pull technique does not have that limitation.

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Another advantage of the hydroxocobalamin push–pull technique is that it enables the SF sampling during local anesthesia, in contrast to arthroscopic SF sampling where general anesthesia is often advised. The hydroxocobalamin push–pull technique functions as an arthrocentesis that also allows for installation of intra-articular medications after the SF sampling.

It is important to retrieve samples of high quality to increase method sensitivity and specificity. Correct intra-articular cannula position is vital for sampling and to limit blood contamination. To achieve this, MRI and ultrasound-guided injections have been proposed [6,7]. Also CT-guidance [8,9] has been an option, although radiation is high.

A general concern to the push–pull hydroxocobalamin technique is the fact that some washing solution persists in the joint after the intervention that may cause transient symptoms and functional problems. All previous studies dealing with the hydroxocobalamin push–pull technique has focused on the technical aspects and SF fluid recovery, but less attention has been paid to side-effects and patient discomfort. As the method is being increasingly used, solid knowledge of both subjective and objective consequences of the technique is important for patient information and information to Ethical Committees. We are also concerned about the potentially high radiation dose patients receive when CT-guidance is used and speculate if CBCT could provide the same information at lower radiation.

The present study was part of a project on SF sampling from the TMJ in healthy individuals and was done on the same subjects [10]. The objectives of this second part of the study were primarily to assess the subjects' discomfort and side-effects of the hydroxocobalamin push–pull technique and, secondly, to evaluate the use of CBCT as control of intra-capsular cannula placement.

Materials and methods

Subjects

Twenty healthy adults, eight females and 12 males, with a median (25^{th}/75^{th} percentile) age of 23 (22/25) years voluntarily agreed to participate in the present study. This group was selected with the purpose of studying cytokine levels in healthy TMJs. Inclusion criteria were healthy subjects with no previous history of pain from temporomandibular joint disorders (TMD) [11], but individuals with non-symptomatic joint clicking and self-reported occasional bruxism were accepted because of the high frequency of these clinical findings in the population [12]. Exclusion criteria were subjects with subjective signs of TMD and current systemic diseases. All included subjects gave their informed consent and all procedures were approved by the Danish Scientific Ethical Committee (approval # 20100002).

Questionnaires pre- and post-intervention

All subjects were clinically examined for TMD and completed a standardized questionnaire routinely used for diagnosing TMJ pathology and growth abnormalities at the Centre for Dento- and Craniofacial Growth Anomalies at the Section of Orthodontics, Aarhus University, Denmark. The questionnaire and examination protocol is based on the extensively validated RDC/TMD [11], but modified specifically in areas of interest to the group of patients examined (e.g. facial asymmetries and related malocclusions). The questionnaire and examination protocol has been described previously [13-16] and is divided into two parts. The first, subjective part features the subject's self-assessment of the present TMJ status (function, sounds and pain/tenderness) and the second, objective part constitutes clinical parameters assessed by the examiner, e.g. joint clicking, maximal mouth opening capacity, pain on palpation. The mandibular range of motion measurements were maximal unassisted mouth opening, maximal laterotrusion and maximal protrusion, all measured with a ruler. The horizontal overjet, vertical overbite and any mid-line deviation were measured to the nearest 0.5 mm.

Two weeks after the intervention, all subjects were clinically examined after the diagnostic questionnaires were completed again in order to evaluate if the procedure had caused subjective or objective signs of TMD. The same operator conducted both clinical examinations.

At follow-up, the subjects completed a second questionnaire to accurately evaluate the subjective experience of the entire procedure. This questionnaire was developed for the purpose of this study. It included questions regarding pain and discomfort using visual analogue scales (VAS, 0–100 mm: 'no pain' to 'worst possible pain'), questions in categorical boxes on pain duration, pain localization on a face-drawing and subjects could describe experiences and discomfort in free text.

Cannula placement and joint irrigation

The SF sampling was performed with the push–pull technique as described by Alstergren et al. [2,17]. In short, two experienced and specially trained operators placed a cannula on either side in the upper joint compartment of each TMJ after disinfecting the skin with ethanol and 5% chlorhexidine and auriculotemporal block with 2 mL on each side with Lidocaine (20 mg/mL). The joint compartments were washed with a washing solution comprising of 2 mL Behepan® (hydroxocobalamin 1 mg/mL; Kabi Pharmacia, Uppsala, Sweden) mixed with 9 mL of physiological saline; 1 mL of washing solution was slowly injected into the joint compartment through a stop-cock valve. The valve was then turned and as much fluid as possible

was aspirated, after which the valve was opened again and the procedure repeated three more times, the total amount of washing solution used was, thereby, 4 mL on each side [2,17]. The aspirate was then centrifuged (1500 g for 10 min) and the supernatants were was stored at 80°C. However, the content of the SF was not a part of the present investigation and the results are published elsewhere [10].

CBCT

The SF sampling procedure was conducted in a room with a NewTom 5G CBCT scanner (NewTom 5G, QR, Verona, Italy). In order to evaluate the position of the cannula used for retrieving the SF sample the subject was seated in the scanner chair and after the cannula placement and sample procedure the subject was lowered to supine position and scanned with an open mouth and a bite block between the teeth using a 15 × 12 inch field of view while the cannulas were still positioned in the TMJs. Scanning time was ~ 15 s.

Cannula position

The cannula position was assessed on three-dimensional CBCT reconstructions in both the sagittal, coronal and vertical planes. For the sagittal plane, the cannula position was assessed to be in the anterior third, the middle third or the posterior of the articular fossa (Figure 1A). In the coronal plane the cannula tip was assessed to be in the medial, middle, or lateral third (Figure 1B), and for the vertical it was assessed to be in the fossa or below (the reference line being a line between the articular eminence and the petrotympanic fissure anterior to the external auditory meatus (Figure 1A).

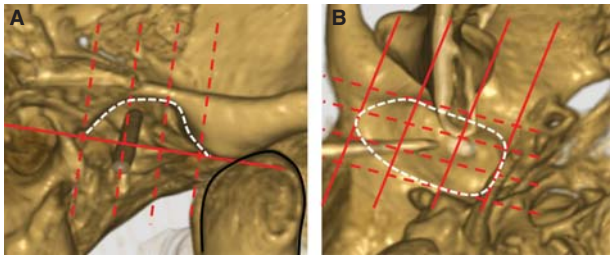

Figure 1. The 3D CBCT reconstruction of a TMJ area with an intra-articular placed cannula. (A) The TMJ area seen from the sagittal view with the red dotted lines defining the sagittal thirds (anterior, middle, and posterior) and the vertical dimensions (within the fossa or below) defined by a straight line between the articular eminence and the petrotympanic fissure anterior to the external auditory meatus. The mandibular condyle is shown with black out-line and is translated onto the articular eminence and the articular fossa is outlined with a white dotted line. (B) The TMJ area seen from axial view below defining the coronal aspect of the cannula position. The sagittal thirds are shown in red dotted lines and the coronal thirds (medial, middle and lateral) are indicated by red full lines. For this cannula it would be placed in the middle third sagittally and coronally and within the fossa.

Statistics

All numerical parameters investigated were tested for normality using the Shapiro-Wilk test. In cases of non-normally distributed data, non-parametric statistics were applied with the Wilcoxon signed-rank test for group differences and Spearman's rho for correlation assessment. For normally distributed data the paired Students *t*-test was used. For the qualitative data collection the free texts in the questionnaires were grouped into statements where the meaning was the same and compared in a semi-quantitative manner.

The statistics program Statistical Package for Social Sciences (SPSS® Statistics, IBM® version 20, Chicago, Illinois, USA) was used for all calculations. For all parameters, a $p < 0.05$ was considered significant.

Results

Questionnaires pre- and post-intervention

Four subjects reported a history of TMJ clicking without other symptoms in a total of five joints and eight reported occasional asymptomatic nighttime bruxism. None of the subjects had previously consulted a dentist for diagnosis or treatment of their clicking or bruxism. Otherwise, no subjects showed signs of TMD, all had normal mandibular range of motion and all subjects entered the study.

Symptoms and pain

At the follow-up, all subjects reported that symptoms had been present since the intervention. Nine subjects reported that all symptoms had disappeared within 24 h, three subjects within the first 48 h after intervention, three subjects after 2–3 days, one subject after 5 days and four subjects reported symptoms persisting up to 1 week after intervention. No subjects reported symptoms after the 7th day (Figure 2). No gender-differences were found.

The distribution of pain and discomfort levels can be seen in Figure 3. Four subjects reported no pain after the procedure and four other subjects reported a pain-intensity below 5 mm on a 0–100 VAS.

The two subjects reporting the highest pain level all had resolution of the pain within the first day and the discomfort disappeared within 48 h. Looking at the distribution of reported discomfort (Figure 3), the subjects seem to be divided into two groups: a lower discomfort group (< 30 mm VAS, n = 11; median discomfort: 17, 25th and 75th percentile: 10 and 22) and a higher discomfort group (> 30 mm VAS, n = 9; median discomfort: 60, 25th and 75th percentiles: 53 and 65). There were no gender differences. The subjects with a high degree of discomfort did not have

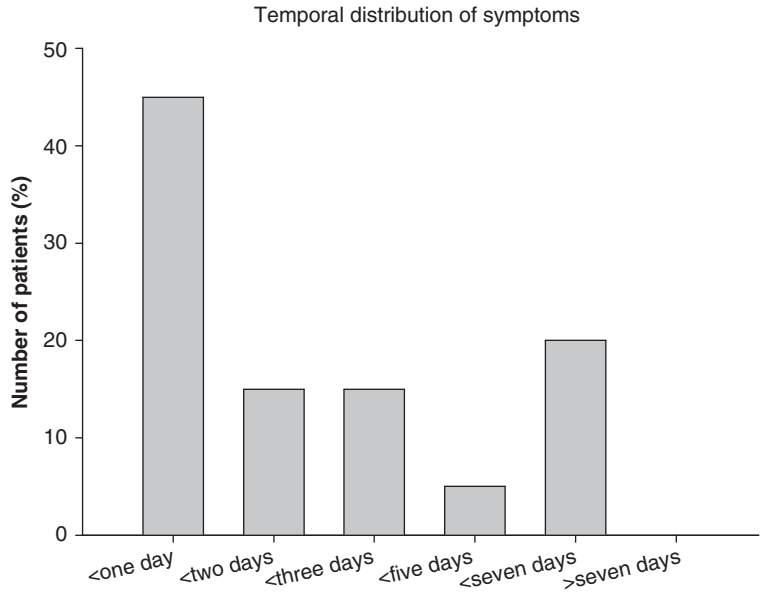

Figure 2. Duration of post-operative symptoms after TMJ SF sampling in 20 healthy young adult volunteers. Three subjects who reported symptoms for up to 1 week experienced noises from the TMJ as their primary concern and one reported 'extreme' TMJ pain on mandibular movements. None of the subjects reported symptoms for more than a week.

significantly higher pain intensity. The discomfort and pain intensity levels were not correlated ($p = 0.95$).

The subjects were asked to describe in their own words what the unpleasant parts of the study were. These statements were then grouped in the following categories. The response 'other' covers: many appointments (information, intervention and control), dizziness during the procedure, the bite block, dryness in the mouth or tightness of the masticatory muscles (Figure 4).

Facial paresis would be considered a significant adverse effect of treatment; however, it was due to the anesthesia which was without any vaso-constrictor and, therefore, the duration was only ~ 20 min. We, therefore, do not consider it an adverse effect, but a rather frequent and expected incidence such as a numb lip after dental anesthesia.

Placement of the pain and discomfort as reported by the subjects are shown in Figure 5.

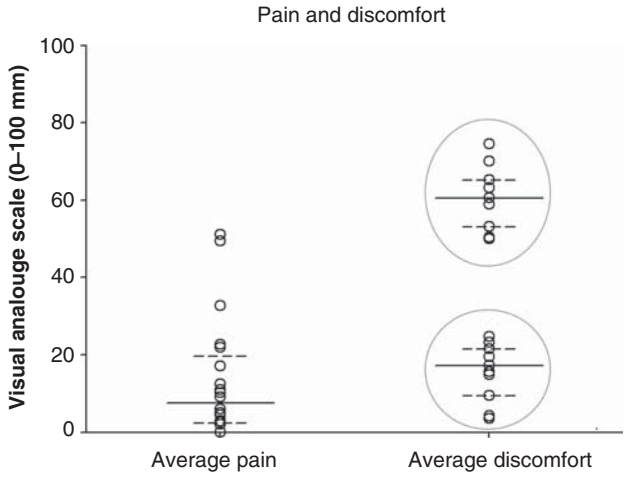

Figure 3. Distribution of pain intensity and discomfort levels expressed by the healthy subjects on a 0–100 visual analogue scale after TMJ synovial fluid sampling ($n = 20$). The average discomfort shows a clear division of the subjects into two groups: a higher discomfort group and a lower discomfort group, which are encircled. For all groups the median is shown with a bar and 25th and 75th percentiles are shown with broken bars.

Clinical examination

The clinical examination found a clicking in five joints before intervention. At follow-up 2 weeks after the intervention three joints were diagnosed with clicking. There were no changes in the opening capacity or laterotrusion. The maximal protrusion capability statistically improved after the intervention, but all other parameters were unchanged (Table I).

CBCT data

The CBCT scans showed a large variation of needle position in relation to the TMJ bony structures.

Two cannulas were undoubtedly placed outside the joint and, therefore, only 38 cannulas were evaluated. In the sagittal plane, 10 were placed in the anterior third, 25 were placed in the middle third and three were placed in the posterior third. In the coronal plane, one was placed in the medial third, 32 were placed in the middle third and five were placed in the lateral third. In the vertical plane, 24 were placed within the fossa and 14 below the fossa.

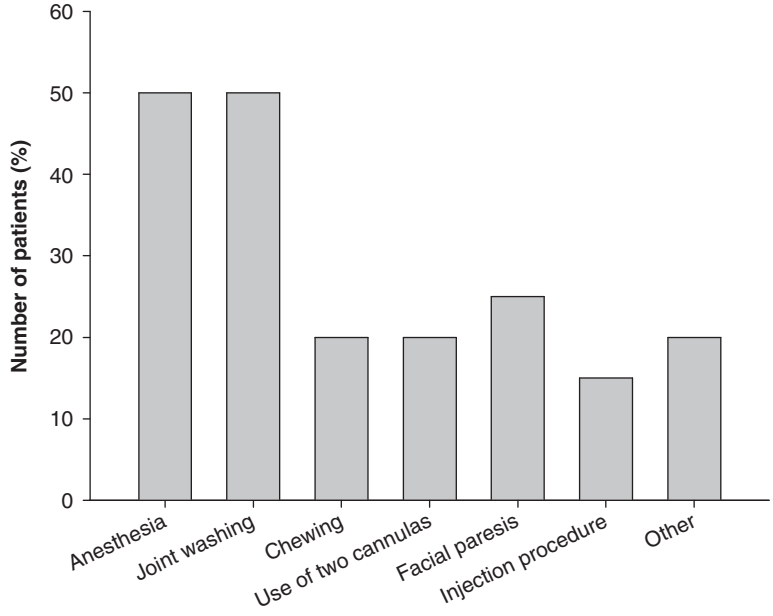

Figure 4. Categories of unpleasant events following temporomandibular joint synovial fluid sampling as reported by the subjects (one subject can be represented in more than one group).

Discussion

This study shows that the hydroxocobalamin push–pull SF sampling procedure results in minor, transient symptoms which can last for up to 1 week after the procedure. No serious adverse events were registered.

We consider that the cannula positioning was sufficiently appropriate, especially since clinically the intra-articular location of the cannula tip was determined by (i) the requirement of only a low-force injection and (ii) the possibility to aspirate the washing solution immediately after injection. The cannula position might have changed to some degree from the sampling to the CBCT imaging which makes the cannula positioning in the CBCT imaging somewhat uncertain regarding the position during sampling.

The primary functions of SF are lubrication and nutrition of the articular joint tissues. SF is a combination of a plasma ultrafiltrate, hyaluronic acid and lubricin that are secreted by the synoviocytes. In healthy conditions, the SF concentration of *most* small molecules is similar to the concentration in plasma [18]. TMJ SF sampling enables investigation of joint pathology, disease progression and aetiology and has been used in different TMJ pathologies [1,19-21]. The number of studies on TMJ SF is rather large; however, to our knowledge, no studies have focused on the subjective experience of the patients undergoing SF sampling. Therefore, we set out to investigate this in healthy subjects as a baseline for other studies, to use for patient information before the procedure and to be used for future ethical committee applications.

The TMJ has an upper and lower joint compartment divided by the articular disc. The cannula position was aimed to be in the upper joint

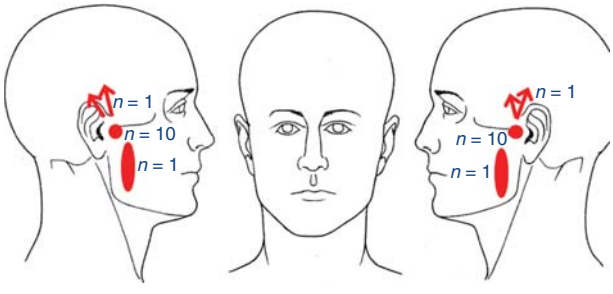

Figure 5. Pain location during and after temporomandibular joint synovial fluid sampling. One subject also reported pain from the masseter area and another subject reported radiating pain in the temporalis area originating from the TMJ area; these radiating symptoms, however, disappeared quickly after the injections. Of the 20 subjects, only 10 completed the facial drawing.

Table I. Mandibular range of motion before and after TMJ SF sampling in 20 healthy adult volunteers. Laterotrusion is reported as a mean between left and right sides.

	Before			After		
		Percentiles			Percentiles	
	Median	25th	75th	Median	25th	75th
Maximum mouth opening	57	55	60	56	55	59
Laterotrusion	10	9	12	11	8	11
Protrusion	9	7	10	10*	9	11

* Statistical significant difference compared to the measures before intervention (Wilcoxon signed rank, $p > 0.001$).

compartment, which is a gap between the articular fossa and the disc tissue. In relation to the bony structures the cannula was supposed to be positioned in the fossa and a large variation was expected to be found as the subjects had an open mouth during the acquisition of the images.

We allowed inclusion of subjects with non-symptomatic TMJ clicking due to the high prevalence of non-symptomatic TMJ clicking and non-symptomatic disc displacement without reduction in the general population [12]. The subjects were recruited online at www.forsøgsperson.dk and at Aarhus University, Denmark, with posters clearly showing the exclusion criteria and, therefore, no subjects with painful TMD volunteered.

An unexpected finding was that the maximal protrusion capability was significantly improved after the intervention. Arthrocentesis has proved an effective tool for normalization of TMJ function in TMD patients [22]; however, we do not attribute this change in protrusion capacity in normal subjects to be caused by the intervention, but rather as a random and irrelevant finding [16,23]. Although statistically significant, this improvement in protrusion is not considered to be of clinical importance [16,23].

We defined symptoms as subjective change in mandibular function, pain or discomfort. Discomfort was defined as all non-painful events which could be related to the study. Discomfort, therefore, encompasses a large group of findings as feeling of altered occlusion, joint sounds, pressure in the joints, mild pain/soreness when the jaw is severely manipulated to either side or maximal opening, etc.

In nine of 20 subjects, symptoms resolved within the first 24 hours. The subjects' main complaints were generally a change in occlusion, pain when biting hard or during 'extreme' mandibular movements as well as joint sounds (reported as 'spongy', 'crackling' or 'squeaking'). The subjects who reported symptoms of up to 1 week of duration reported joint sounds as the primary symptom and only one reported pain on extreme mandibular movements after the first day.

TMJ pain levels were generally low after the intervention. The subjects reporting the highest pain intensity reported that the pain had completely resolved within the first day. Therefore, higher pain intensity levels can be expected for a short period of time if they occur.

From the subjective part of the questionnaire the procedures related to the intervention (local anaesthesia, pressure during joint washing, use of two cannulas, facial paresis, injection procedure) caused the most common complaints. Therefore, when doing TMJ SF sampling, especially in younger children for example in combination with intra-articular steroid application, general anaesthesia may be advised; especially if both joints are to be injected.

The use of CBCT as a verification of the cannula position seems unable to confirm the correct position when open mouth recordings are used. We only found two cases where the cannula for sure was outside the joint, an assessment which could be done without the CBCT. Furthermore, the use of CBCT will demand a specific set-up in the scanner, with the patient in a supine position optimal for both the insertion procedure and the scanning, which is not feasible for routine use. Additionally, clinically we registered a change in cannula position from the sitting position of the subject where the cannula was inserted and the supine position for the scanning, although the cannula position related to the soft tissue probably was the same. The essential information is the relation to the discus and whether the cannula is situated in the superior compartment. Due to movements in the soft tissue during the procedure, only a rough estimate of the position could be done. Even if soft tissue movements can be eliminated, radiographic assessment is inferior to MRI information. Ultrasound may be a promising method to define the correct position for injection.

CT has been used to verify intra-articular placement of the cannula [8,9]. In these studies the cannula must be placed between the condyle and fossa as the mouth is closed or only slightly opened. As the push–pull procedure is done with an open mouth, the mandibular condyle had translated onto the articular eminence and, hence, the soft tissues of the TMJ were stretched and the cannula tip is, therefore, impossible to verify within the joint. Therefore, we suggest others investigating the relation between cannula, condyle and fossa to do this with the mouth closed or slightly open. However, the 'correct' position cannot be verified using CBCT. The soft tissues are not visualized and, therefore, even a 'perfect' average position cannot predict if, in fact, a cannula is positioned intra-articular. Use of TMJ injections in TMD patients may have a different success rate when compared to healthy individuals. In early stages of TMJ pathology, correct cannula position may be easier compared to later stages in the TMJ pathology due to a narrow joint space, intra-articular adhesions, etc.

Conclusion

TMJ SF sampling using the hydroxocobalamin push–pull method was found to be safe, resulting in only minor and transient symptoms.

CBCT offers additional information of the position of the cannula in relation to the hard tissue, but with a large variation. No clinical benefits concerning the correct position of the cannula in relation to the upper joint compartment and the disc seems to be provided and CBCT is not recommended for this procedure.

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