Journal of Cranio-Maxillo-Facial Surgery 42 (2014) 1402–1407

Contents lists available at ScienceDirect

Journal of Cranio-Maxillo-Facial Surgery

journal homepage: www.jcmfs.com

Correlation between bony changes measured with cone beam computed tomography and clinical dysfunction index in patients with temporomandibular joint osteoarthritis

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ARTICLE INFO

Article history:
Paper received 31 January 2014
Accepted 8 April 2014

Keywords:
Cone beam computed tomography
Temporomandibular joint
Osteoarthritis

ABSTRACT

Objectives: To investigate the correlation between clinical dysfunction index (Di) and condylar bony changes, glenoid fossa bony changes and joint space changes.
Methods: Clinical data and cone beam computed tomography (CBCT) images of 240 patients with temporomandibular joint osteoarthritis (TMJ OA) were analyzed. The patients were assigned a score of Helkimo's clinical Di ranging from 1 to 25 and thereafter divided into 3 groups by the degree of Helkimo's Di. The condylar bony changes observed with CBCT were graded by the classification method of Koyama et al. Glenoid fossa bony changes and joint space changes were both classified as "positive" or "negative". Spearman's rank correlation test was used to correlate the score or degree of Helkimo's Di with the maximum condylar bony changes, glenoid fossa bony changes, and joint space changes.
Results: There was a significant correlation between the Helkimo's Di score and the maximum condylar bony changes ($P \leq 0.0001$) and glenoid fossa bony changes ($P \leq 0.0001$), and there was a poor correlation between the Helkimo's Di score and joint space changes ($P = 0.184$). Furthermore, there was a significant correlation between the degree of Helkimo's Di and the maximum condylar bony changes ($P \leq 0.0001$) and glenoid fossa bony changes ($P \leq 0.0001$), but there was a poor correlation between the degree of Helkimo's Di and joint space changes ($P = 0.346$).
Conclusions: Both the score and degree of Helkimo's Di were highly correlated with maximum condylar changes and glenoid fossa bony changes, but not with joint space changes.

1. Introduction

The temporomandibular joint (TMJ), which comprises the mandibular condyle, the inferior component, and the temporal bone forming the superior component, is one of the most complex joints in the body (Wu et al., 2012). Temporomandibular disorders (TMD) are clinically manifested by craniofacial pain, limited mouth opening, and TMJ click occurring in the TMJ, masticatory muscles and other relevant structures (John et al., 2007). Approximately 10%–70% of the population presents with some type of TMD, such as myofascial dysfunction, internal derangement or degenerative joint disease. TMD is epidemic in women between 20 and 40 years old (Barros Vde et al., 2009). Osteoarthritis of the TMJ (TMJ OA) is a degenerative joint disease and is an age-related disorder characterized by the progressive destruction of articular tissues in the mandibular condyle and glenoid fossa often brought about by increased loading on the joint (Okeson, 2008). With advanced degeneration, loss of the subchondral cortical layer, erosion and other radiographic signs will occur (Stegenga et al., 1989, 1991).

Cone beam computed tomography (CBCT), a new imaging modality used in dentistry, is thought to have high dimensional accuracy in measuring facial structures, including the TMJ (Lascala et al., 2004) and may be the modality of choice for assessing the

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http://dx.doi.org/10.1016/j.jcms.2014.04.001
1010-5182/

osseous morphology of the TMJ (Hilgers et al., 2005). CBCT is increasingly popular for use in TMJ imaging.

Many authors have noted the need to have a standardized classification for assessing the signs and symptoms of TMD, measuring and comparing the severity of TMJ disorders among populations, and assessing patients' condition after treatment; they also require a useful implement to study the etiological factors (Miller et al., 2000). Helkimo was a pioneer in developing indexes to measure the severity of TMJ disorders and pain in TMJ. Helkimo's clinical dysfunction index (Di), developed in 1974, is the first such relevant index (Helkimo, 1974). Di is a functional evaluation of the masticatory system and classifies individuals on 5 basic signs, including impaired range of mandibular movement, TMJ function impairment, pain during mandibular movement, TMJ pain during palpation, and muscle tenderness (Shahidi et al., 2013).

Many researchers have evaluated the correlation between the presence of symptoms or signs of TMD and radiographic changes in the TMJ using different imaging modalities (Crow et al., 2005; Palconet et al., 2012; Ohlmann et al., 2006; Huh et al., 2003; Emshoff et al., 2003), and the outcomes were controversial. Some studies demonstrated correlations between symptoms or signs such as pain intensity and the radiographic findings in OA, disc displacement and joint effusions (Huh et al., 2003; Emshoff et al., 2003), while others failed to find a correlation (Crow et al., 2005; Palconet et al., 2012; Ohlmann et al., 2006).

The aim of this study is to determine whether bony changes, including condylar bony changes, glenoid fossa bony changes and joint space changes, measured with CBCT are correlated with Helkimo's clinical Di in TMJ OA patients.

2. Materials and methods

2.1. Study design

The study was approved by the Ethics Committee of the West China Hospital of Stomatology at Sichuan University (WCHSIRB-D-2013-092). CBCT images and clinical records of TMJ OA patients who sought treatment at the Hospital's Orofacial Pain Clinic from July 2012 to July 2013 were reviewed in this study. The inclusion criteria were: diagnosis of TMJ OA according to the Research Diagnostic Criteria for TMDs (RDC/TMD axis I group IIIb), defined by the presence of arthralgia and either TMJ crepitation or CBCT bony changes, including erosion, flattening or sclerosis of joint surfaces or osteophyte formation (Dworkin and LeResche, 1992). The exclusion criteria were the following: other types of TMD such as myofascial disorder syndrome but normal TMJ structure or rheumatic diseases; a history of TMJ surgery, condylar fracture, jaw trauma or polyarthritis; subjects with missing data.

The clinical signs, including TMJ function impairment, muscle tenderness during palpation, TMJ pain during palpation, pain during mandibular movement and range of mandibular mobility (5 items), based on the definition of Helkimo's clinical Di (Helkimo, 1974), were extracted from all included patients. Depending on the presence and/or severity of these clinical symptoms, each patient was assigned a score of 0, 1 or 5 points for each item. Depending on the total score, the individuals were divided into 4 groups:

Di 0: 0 point – absence of clinical symptoms;
Di 1: 1–4 points – mild dysfunction symptoms;
Di 2: 5–9 points – moderate dysfunction symptoms;
Di 3: 10–25 points – acute/serious dysfunction symptoms.

The CBCT images of the bilateral TMJ were obtained with a 3D Accuitomo CBCT machine (MCT-1 [EX-2F], Morita Manufacturing Corp, Kyoto, Japan) with image capture parameters set at 85.0 kV and 4.0 mA and an exposure time of 17.5 s. The voxel size was 0.125 mm, and the slice thickness was 1.0 mm. The field of view (FOV) size was 120 mm. The images were analyzed with inbuilt software (i-Dixel one volume viewer 1.5.0) using a Dell Precision T5400 workstation (Dell, Round Rock, TX, USA). Axial, coronal, and sagittal 2D sectional images were displayed on a 32-inch Dell LCD screen with a resolution of 1280 × 1024 pixels in a dark room. Two independent oral and maxillofacial specialists interpreted all of the images. Any doubt about which classification to assign was decisively evaluated by a third specialist. Based on the CBCT images, the type of condylar bony changes was classified using the classification system of Koyama et al. (Koyama et al., 2007) as follows:

Type N: No proliferation or thickening on the cortical surface of the condyle; displaying typical morphology;
Type F: Flattened contour at the antero- and/or postero-superior portions of the condyle;
Type E: Proliferation or partial hypodense change with or without roughening on the cortical surface of the condyle;
Type D: A deformed contour on the condyle, such as a beak, without proliferation or partial hypodense change on the condylar surface;
Type S: Type D accompanied by Type E.

Glenoid fossa bony changes were classified as "positive" in the presence of flattening, erosion and/or sclerosis in either joint, or as "negative" if the glenoid fossa was normal in both joints. Joint space changes were classified as "positive" in the presence of the deviation of joint space, including increase, reduction or bony contact between the condyle head and mandibular fossa in either joint, or as "negative" if the joint space was normal in both joints.

2.2. Statistical analysis

The statistical analysis was conducted using SPSS 15.0 (SPSS Inc., Chicago, USA) software. Only the maximum bony change of the condyle was used as a covariate. Spearman's rank correlation test was used to correlate both the scores and degrees of Helkimo's Di with the maximum condylar bony change, glenoid fossa bony changes and joint space changes.

For testing inter-examiner reliability, the measurements by the two specialists for interpreting the CBCT images were evaluated by the Kappa test. For testing intra-examiner reliability, 72 subjects were randomly selected 2 weeks after the initial review, and their radiological reports were reviewed again under the same standardized conditions. The consistency between the first and second measurements of each specialist was also evaluated by the Kappa test.

Table 1
Kappa coefficients of inter- and intra-examiner reliability of different variables.

Variables	Kappa value	Error	*P* value
Inter-examiner reliability ($N = 240$)			
Specialist 1 vs. Specialist 2			
Condylar bony changes	0.847	0.028	≤0.0001
Fossa glenoid bony changes	0.848	0.041	≤0.0001
Joint space changes	0.943	0.025	≤0.0001
Intra-examiner reliability ($N = 72$)			
Specialist 1			
Condylar bony changes	0.922	0.024	≤0.0001
Fossa glenoid bony changes	0.954	0.020	≤0.0001
Joint space changes	0.954	0.020	≤0.0001
Specialist 2			
Condylar bony changes	0.896	0.028	≤0.0001
Fossa glenoid bony changes	0.900	0.028	≤0.0001
Joint space changes	0.908	0.027	≤0.0001