King Saud University Journal of Dental Sciences (2013) 4, 81–85

King Saud University

King Saud University Journal of Dental Sciences

www.ksu.edu.sa
www.sciencedirect.com

ORIGINAL ARTICLE

A retrospective study of the prevalence and reliability of the diagnosis of soft tissue calcification of the temporomandibular joint in cone beam computed tomography images

Asma'a A. Al-Ekrish *

Dept. of Oral Medicine and Diagnostic Sciences, College of Dentistry, King Saud University, P.O. Box 60169, Riyadh 11545, Saudi Arabia

Received 23 November 2012; revised 9 February 2013; accepted 19 March 2013
Available online 20 April 2013

KEYWORDS

Cone beam CT;
TMJ;
Pathologic calcification;
Reliability and validity

Abstract *Objective:* To investigate the prevalence and reliability of diagnosis of soft tissue calcification of the temporomandibular joint (TMJ) in cone beam computed tomography (CBCT) images of TMJ and non-TMJ patients.

Materials and methods: All retrievable CBCT data sets acquired during a period of 2 years and 7 months were evaluated for the presence of a soft tissue calcification of the TMJs. Axial and corrected sagittal and coronal images were viewed as 2 mm maximum intensity projection images throughout the entire thickness of each joint by a single examiner. Fifty randomly selected cases were examined again by the same examiner using the same protocol. Descriptive statistics were used to calculate the percentage of the cases diagnosed with TMJ soft tissue calcification during both examinations. The chi square test was used to calculate the intra-observer agreement between the two examinations.

Results: The total sample size was 491 joints. The first and second examinations yielded a diagnosis of calcification present in 12% and 34% of cases, respectively. Cross-tabulation of the results from the first and second examinations indicated 34% of the readings were not in agreement. The chi square test indicated no significant correlation between the results of the first and second examination (p-value = 0.626). With regards to the cases diagnosed with calcification, 94% of the cases were in disagreement.

* Tel.: +966 1 4677423.
E-mail address: asma.alekrish@gmail.com

Peer review under responsibility of King Saud University.

ELSEVIER Production and hosting by Elsevier

2210-8157 © 2013 Production and hosting by Elsevier B.V. on behalf of King Saud University.
http://dx.doi.org/10.1016/j.ksujds.2013.03.003

Conclusions: The CBCT images produced by the device used in the present study were of low reliability for the diagnosis of TMJ soft tissue calcification. Studies are needed to develop CBCT protocols which may accurately and reliably demonstrate such calcification.

© 2013 Production and hosting by Elsevier B.V. on behalf of King Saud University.

1. Introduction

Calcification of the soft tissue components of the temporomandibular joint (TMJ) may occur in association with various conditions. Synovial chondromatosis (SC),[1] calcium pyrophosphate arthropathy (CPPA) (pseudogout),[2] and osteochondritis dissecans (OCD)[3,4] are conditions known to be associated with loose articular bodies. Calcification of the articular disk has also been reported by some researchers.[5–7] Disk perforation, articular dysfunctions, and disk degeneration, which may occur as a result of aging or mechanical stress, have all been suggested as possible causes for the disk calcification.[5,6]

Although loose joint bodies of the TMJ are considered to be rare, and mostly associated with SC, CPPA, or OCD,[8,9] calcification of the articular disk has been reportedly observed in 37% of a sample of cadaver disks.[5] Cone beam computed tomography has been demonstrated to be a highly reliable, and one of the most accurate, imaging modalities for depiction of osseous TMJ morphology, even compared with medical grade computed tomography (CT).[10,11] At the time of writing, however, the author is unaware of any published studies investigating the prevalence or reliability of detection of soft tissue calcification in CBCT examinations of the TMJ. Knowledge of such prevalence may aid in better understanding the clinical significance of such calcification when it occurs alone or in association with disease conditions or other findings. Therefore the aim of the present study was to investigate the prevalence and reliability of diagnosis of soft tissue calcification of the TMJ in the CBCT datasets of TMJ and non-TMJ patients undergoing a CBCT examination for any reason.

2. Materials and methods

The retrievable data sets of all patients imaged with CBCT at the Radiology Department of the King Saud University College of Dentistry, between April 5, 2008 and November 9, 2010, were viewed and evaluated in consideration for inclusion in the study. The images of the bilateral TMJs were viewed independently of each other, and were included regardless of age, gender, existing medical conditions, or reason for the CBCT examination. However individual TMJs were excluded if the TMJ was deformed due to developmental or acquired abnormalities (including ankylosis, fracture, or condylectomy), or if the presence of artifacts degraded image quality to such a degree as to render the TMJ images non-diagnostic. In cases where the CBCT examination was performed as part of a parotid sialography procedure, the TMJ ipsilateral to the subject parotid gland was excluded from the study, as the contrast media may interfere with the visibility of soft tissue calcification in the TMJ region.

Approval for use of the patients' images for research purposes was obtained from the College of Dentistry Research Center. All the patients had been imaged in a CBCT device (Iluma, Imtek Imaging, 3M Company, USA) with a large field of view (FOV) and flat panel detector. The size of the detector was 19×24 cm, and was composed of 127 micron amorphous silicon. Some patients had been imaged with the full FOV, while others had the FOV collimated to one-half its height. The X-ray source focal spot size was 0.3 mm. The images had been acquired using 3.8 mA and 120 kVp. The scan time was either 39.9 s, yielding 602 basis images, or 20 s, yielding 301 basis images. The reconstructed voxel size was 0.29 mm.

For the present study, the reconstructed axial projection images were then processed with reformatting software (IlumaVision 3-D, Imtek Imaging, 3M Company, USA) to obtain corrected sagittal and coronal sections of the TMJ perpendicular and parallel to the long axis of the condylar head, respectively. The axial, sagittal, and coronal sections were all viewed as maximum intensity projection (MIP) images 2 mm in thickness.

Each TMJ was examined by a single examiner, an oral and maxillofacial radiologist with 8 years experience in interpretation of CT/CBCT images. The images were viewed on a liquid crystal display (LCD) monitor (Dell Ultrasharp 2408WFP-24″ Widescreen Flat Panel Monitors) in a dimly lit room. And, if it was necessary to improve the clarity of the images, the examiner adjusted contrast, density, and magnification of the images, as well as the thickness and orientation of the image slices. Each joint was subjectively evaluated for the presence or absence of soft tissue calcification by examination of the axial, sagittal, and coronal images throughout the entire thickness of the joint. For a radiopacity to be diagnosed as a soft tissue calcification, it had to be found in the region of the TMJ, and not contacting any bony structure. The radiopacity had to be visible in image sections of more than one plane, and had to appear either larger than or more radiodense than the surrounding pattern of image noise. Two examples of the images detected during the first examination are presented in Figs. 1 and 2.

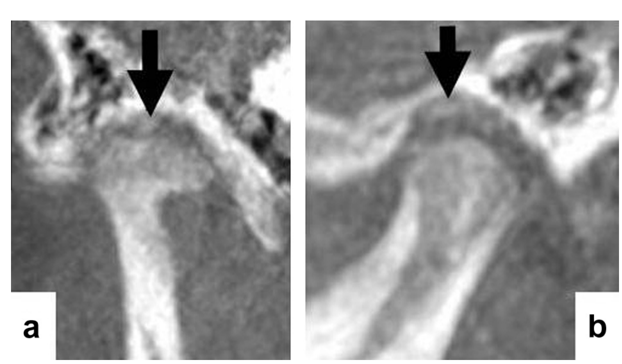

Figure 1 Corrected coronal (a) and sagittal (b) CBCT sectional images (maximum intensity projections, 2 mm in thickness) showing examples of radiopacities (marked by arrows) diagnosed as soft tissue calcification because they were larger in size than the surrounding image noise pattern.

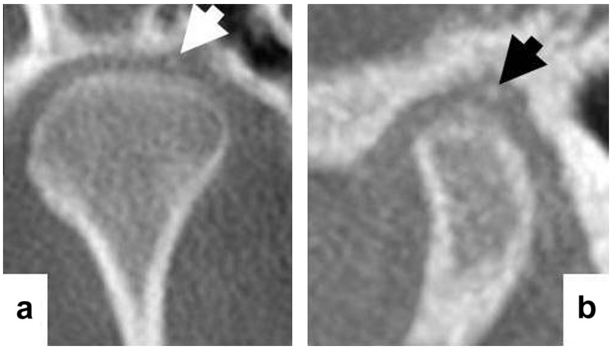

Figure 2 Corrected coronal (a) and sagittal (b) CBCT sectional images (maximum intensity projections, 2 mm in thickness) showing examples of radiopacities (marked by arrows) diagnosed as soft tissue calcification because they were more radiopaque than the surrounding image noise pattern.

Table 1 Causes of exclusion of TMJ samples.

Cause	Number of excluded samples
Motion artifacts degrading image quality	151
Mandibular/condylar fractures	5
Contrast media from sialography in proximity	3
Condylectomy (due to ankylosis)	2
Streak artifacts degrading image quality	1
Ankylosis	1
Deformed condyle	1
Ring artifact degrading image quality	1
Total	165

After examination of the entire sample, fifty samples were then randomly selected using an online random number generator (StatTrek.com, http://stattrek.com/statistics/random-number-generator.aspx), and the 50 randomly selected joints were examined a second time by the same examiner, using the same methodology and criteria.

Descriptive statistics were then used to calculate the percentage of the cases diagnosed with TMJ soft tissue calcification during both examinations. The chi square test was used to calculate the intra-observer agreement. Significance was set at a p-value of 0.05.

3. Results

The number of retrievable data sets was 328. Each TMJ was considered independently, for a total of 656 joints. 165 TMJs were excluded for various reasons outlined in Table 1. Thus, the total sample size was $n = 491$.

The first examination yielded a diagnosis of calcification present in 59/491 cases (12%). The second examination yielded a diagnosis of calcification present in 17/50 cases (34%).

3.1. Intra-observer reliability

Cross-tabulation of the results from the first and second examinations was performed and 34% of the readings were not in agreement. Using the chi square test a p-value of 0.626 was obtained, which indicates no significant correlation between the results of the first and second examination. With regard to the cases diagnosed with calcification, 94% of the cases were in disagreement.

4. Discussion

The present study aimed to investigate the prevalence of soft tissue calcification in CBCT images of the TMJs. It was conducted as a retrospective study and the sample population was designated as dental patients who had previously underwent a CBCT examination for any reason, and whose TMJs were visible in the image data set. Such a design was used in order to avoid exposure of a sample population to ionizing radiation for purely research purposes. As such, the sample population of this study may not be representative of the general population, since it is composed of dental patients who complain from any variety of dental diseases or conditions. So although many of the sample population's TMJs may have been asymptomatic, it is conceivable that the dental condition for which they are under treatment may either directly or indirectly affect the TMJ morphology. However, the ethical restrictions to exposing members of the general population to ionizing radiation with no direct diagnostic or therapeutic benefit to them impose this limitation on the study.

At the time the images were acquired, the only available option for CBCT imaging in the institution was the use of the large FOV, and later on collimation to one-half the height of the FOV. For this reason the TMJs were visible in most CBCT examinations performed at that time.

The main limitation of the present study, however, was the lack of a gold standard to compare the CBCT findings with. Such a limitation is inevitable with live patients because direct examination of the TMJs is not possible without surgical intervention, a procedure which was unwarranted for the general dental population. As such, the accuracy of the diagnoses could not be measured; instead reliability was used as an indirect indicator of the utility of CBCT for diagnosis of the calcification.

Another limitation of the present study is that the results may not be applicable to other CBCT devices. This is an unavoidable limitation of any study involving CBCT image quality because the image noise produced by various CBCT machines is markedly different in magnitude. For Liang et al. (2010) have demonstrated that scanning and reconstruction parameters, in addition to CBCT machine type, may directly influence image quality of the acquired image, which in turn affects the radiographic visibility of anatomical structures and image noise level.[12] Therefore, the results of the low-contrast diagnostic task being investigated in the present study are expected to be affected considerably by such a variation in image quality.

The purpose behind the use of MIP images was to optimize the contrast between the calcification and the surrounding soft tissues. Slices two millimeter in thickness were used because, from experience, it was found that this was the thickness which reduced the amount of noise in the image and at the same time provided optimum contrast between the calcification and surrounding tissues. Thicker images introduced overlapping of adjacent structures, and thinner images had more noise.

The low intra-observer agreement obtained in the present study indicates the lack of reliability of the CBCT images from the study device in the detection of soft tissue calcification of the TMJ. During interpretation of the images, a large degree of uncertainty was faced with suspicion of small, lower density calcification. The amount of noise within the images (even with 40 s exposure) may have been a factor in reducing the detectability of small calcification (0.8 mm or smaller). And although the present study did not measure the accuracy of detection of soft tissue calcification, the lack of reliability of the CBCT images used may be an indicator as to the degree of accuracy. Therefore, the findings of the present study are compatible with the findings of Testaverde et al. (2011) who, in a comparison between medical CT findings with histological examination of TMJs, concluded that medical CT does not find non-calcified loose bodies.[13] The present study's findings are also compatible with the findings of two other studies which compared the results from medical CT images with the histologic samples from the joints of patients histologically diagnosed with synovial chondromatosis, and found that medical CT images demonstrated only one half of the calcification detected histologically.[14,15]

Although CBCT has been found to demonstrate surface osseous changes of the TMJ accurately and reliably,[10,11] increasing FOV and voxel size have both associated with a reduction in the ability to detect early osseous changes.[16,17] Since such factors have been demonstrated to impact such a high-contrast diagnostic task, it is conceivable that a lower contrast task such as detection of soft tissue calcification would be even more adversely affected. And since a large FOV was used in most of the samples of the present study, this may be considered as a possible factor influencing the low reliability.

The present study is the only study the author is aware of that attempted to assess the detectability of TMJ soft tissue calcification in CBCT images, and since the results have indicated very low reliability, studies are needed to investigate the ability of images from various CBCT machines to demonstrate TMJ calcification, as compared to a gold standard of histologic examination of cadaver TMJs. The various exposure and reconstruction parameters need to be investigated independently to develop a CBCT protocol which may accurately and reliably demonstrate calcification within the soft tissues of the TMJ. Furthermore, well-defined diagnostic criteria need to be determined for evaluation of small calcification. The ability to detect small soft tissue calcification of the TMJ using CBCT is necessary because when symptoms of associated conditions occur they are often non-specific, which may lead to a delayed diagnosis and/or intervention of up to 2 years.[18] After development of accurate and reliable CBCT protocols, they may then be utilized to study the prevalence of TMJ soft tissue calcification in TMJ and non-TMJ patients to better understand the clinical significance of such calcification.

5. Conclusions

Diagnosis of TMJ soft tissue calcification from images produced by the CBCT device used in the present study was of low reliability. Studies are needed to develop CBCT protocols which may accurately and reliably demonstrate such calcification.

Acknowledgements

The author wishes to acknowledge Prof. Mohammad Ekram for his valuable advice regarding the manuscript, and Hebah O. Al-Juhani and Roaa Al haidari for their aid in organization of the data used in the study.

References

1. Shah SB, Ramanojam S, Gadre PK, Gadre KS. Synovial chondromatosis of temporomandibular joint: journey through 25 decades and a case report. *J Oral Maxillofac Surg* 2011;**69**:2795–814.
2. Bencardino JT, Hassankhani A. Calcium pyrophosphate dihydrate crystal deposition disease. *Semin Musculoskelet Radiol* 2003;**7**:175–85.
3. Mesgarzadeh M, Sapega AA, Bonakdarpour A, Revesz G, Moyer AH, Maurer AH, et al. Osteochondritis dissecans: analysis of mechanical stability with radiography, scintigraphy, and MR imaging. *Radiology* 1987;**165**:775–80.
4. Schellhas KP, Wilkes CH, Fritts HM, Omlie MR, Lagrotteria LB. MR of osteochondritis dissecans and avascular necrosis of the mandibular condyle. *AJR Am J Roentgenol* 1989;**152**:551–60.
5. Jibiki M, Shimoda S, Nakagawa Y, Kawasaki K, Asada K, Ishibashi K. Calcifications of the disc of the temporomandibular joint. *J Oral Pathol Med* 1999;**28**:413–9.
6. Marchetti C, Bernasconi G, Reguzzoni M. Presence of calcified tissue in the human temporomandibular joint disc. *Arch Oral Biol* 1997;**42**:755–60.
7. Paz ME, Katzberg RW, Tallents RH, Westesson PL, Proskin HM, Murphy WC. Computed tomographic evaluation of the density of the temporomandibular joint meniscus. *Oral Surg Oral Med Oral Pathol* 1988;**66**:519–24.
8. Westesson P, Yamamoto M, Sano T, Okano T. Temporomandibular joint. In: Som P, Curtin H, editors. *Head and neck imaging*. 4th ed. Mosby: St. Louis; 2003.
9. Ahmad M, Hollender L, Anderson Q, Kartha K, Ohrbach R, Truelove EL, et al. Research diagnostic criteria for temporomandibular disorders (RDC/TMD): development of image analysis criteria and examiner reliability for image analysis. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2009;**107**:844–60.
10. Hussain AM, Packota G, Major PW, Flores-Mir C. Role of different imaging modalities in assessment of temporomandibular joint erosions and osteophytes: a systematic review. *Dentomaxillofac Radiol* 2008;**37**:63–71.
11. Katakami K, Shimoda S, Kobayashi K, Kawasaki K. Histological investigation of osseous changes of mandibular condyles with backscattered electron images. *Dentomaxillofac Radiol* 2008;**37**:330–9.
12. Liang X, Jacobs R, Hassan B, Li L, Pauwels R, Corpas L, et al. A comparative evaluation of cone beam computed tomography (CBCT) and multi-slice CT (MSCT) part I. On subjective image quality. *Eur J Radiol* 2010;**75**:265–9.
13. Testaverde L, Perrone A, Caporali L, Ermini A, Izzo L, D'Angeli I, et al. CT and MR findings in synovial chondromatosis of the temporo-mandibular joint: our experience and review of literature. *Eur J Radiol* 2011;**78**:414–8.
14. Meng J, Guo C, Yi B, Zhao Y, Luo H, Ma X. Clinical and radiologic findings of synovial chondromatosis affecting the temporomandibular joint. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2010;**109**:441–8.
15. Ardekian L, Faquin W, Troulis MJ, Kaban LB, August M. Synovial chondromatosis of the temporomandibular joint: report and analysis of eleven cases. *J Oral Maxillofac Surg* 2005;**63**:941–7.

16. Barghan S, Tetradis S, Mallya S. Application of cone beam computed tomography for assessment of the temporomandibular joints. *Aust Dent J* 2012;**57**(Suppl. 1):109–18.
17. Librizzi ZT, Tadinada AS, Valiyaparambil JV, Lurie AG, Mallya SM. Cone-beam computed tomography to detect erosions of the temporomandibular joint: effect of field of view and voxel size on diagnostic efficacy and effective dose. *Am J Orthod Dentofacial Orthop* 2011;**140**:e25–30.
18. Guarda-Nardini L, Piccotti F, Ferronato G, Manfredini D. Synovial chondromatosis of the temporomandibular joint: a case description with systematic literature review. *Int J Oral Maxillofac Surg* 2010;**39**:745–55.