Original article

Clinical application of Cone-beam tomography in disorders of the head of mandible

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Abstract

This article aims to introduce or upgrade health professionals about the applicability of the use of Cone-beam Tomography in clinical and surgical studies of the head of mandible. Due to its location and functionality, the head of mandible has great importance in various specialties and, imaging tests are recommended for therapeutic methods. Regular radiographs show superimposed images of the mandibular region, hampering the morphological assessments. Through more precise images that identify minimal changes, the Cone-beam Tomography is an imaging method that optimizes the routine clinical performance by improving the diagnostic accuracy, since it makes visible three-dimensional bone structures and corrects overlapping areas.

Keywords: Cone-beam tomography, head of mandible, human anatomy, radiology.

1 Introduction

The temporomandibular joint (TMJ) is considered the most complex of the human body, classified as synovial, presenting capsule and articular disk, membrane, synovial fluids and ligaments. In particular, TMJ is a form of connection between the head of mandible (face) and temporal bone (skull), which creates a mechanically stable joint component (ALOMAR, MEDRANO, CABRATOSA et al., 2007).

In the human embryo, between the seventh and eighth weeks of intrauterine life, the condensation of mesenchymal tissue is initiated in order to form the head of mandible, the articular disk and the squamous portion of temporal bone. At this stage, despite the absence of a joint cavity common in the TMJ, it is possible to observe limited movements (MERIDA-VELASCO, RODRIGUEZ-VAZQUES, MERIDA-VELASCO et al., 1999). This joint is constantly remodeled with the advancing age (PIETTE, 1993), and thus has striking morphological differences between adults and children (MENG, LIU, HU et al., 2008).

Computerized tomography (CT) was conceived in the early 1970 by the English engineer Hounsfield, along with the American physicist Comark. This is a diagnostic imaging method that uses X-rays and permits three-dimensional reproduction sections of the human body. Unlike conventional X-rays that project all the structures traversed by the X-ray into a single plan, CT scan shows deep structural relationships by exposing structural layers, especially mineralized tissues (BROOKS, 1993).

Developed in 1998 as a type of Volumetric CT for obtaining images in Odontology, Cone-beam Tomography is based on the emission of Cone-beam technique (MOZZO, PROCACCI, TACCONI et al., 1998), presenting an exposure time to X-rays about 15 times lower than conventional CT method (SCARFE, FARMAN and SUKOVIC, 2006). Thus, although the effective radiation dose of Cone-beam CT varies according to technical specifications selected during the process (relating to field of view, exposure time, milliamperage or kilovoltage) (LUDLOW, DAVIES-LUDLOW, BROOKS et al., 2006), shows significantly lower when compared to traditional CT (SCHULZE, HEILAND, THURMANN, 2004 et al.) and other radiological methods (HATCHER and ABOUDARA, 2004).

The difference between the images of conventional radiology and Cone-beam CT becomes a significant factor in daily practice. Some advantages are possible to be observed: the 3D representation of bone structures, allowing the viewing at different angles and perspectives and correcting overlapping areas (LUDLOW, DAVIES-LUDLOW and BROOKS, 2003). For the morphological analysis of facial bone structures, Cone-beam CT has been the most appropriate imaging method (PARKS, 2000). It enables the analysis of the mandibular contour (Figure 1), its position in the mandibular fossa and the cortical involvement (UTUMI, OLIVEIRA SALES, SHINOHARA et al., 2008), besides visualizing all the other bony structures that are part of the TMJ (HUSSAIN, PACKOTA, MAJOR et al., 2008).

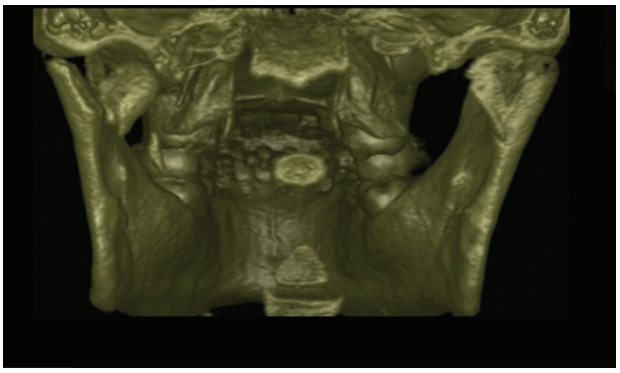

Figure 1. Cone-beam tomography with three-dimensional reconstruction of the posterior face of the head of mandible showing the fracture on the left (arrow).

The TMJ region is one of the regions with great difficulty to obtain images, at least partially, due to the dense bone structures of the skull, especially the petrous part of the temporal bone, which leads to overlapping images (AHLQVIST and ISBERG, 1999). The applicability of Cone-beam CT in Craniofacial Anatomy has become widespread, and is currently indicated for degenerative bone evaluation of TMJ and mandibless, orthodontic treatment planning, dental extractions, dental clinical diagnosis (WHITE, 2008), assessment of the degree of resorption and remodeling bone (BJERKLIN and ERICSON, 2006) and visualization of the upper airway dimension (GARIB, HENRIQUES, JANSON et al., 2005).

2 Correlation between *Cone-beam CT* and clinical aspects of the head of mandible

The association of temporomandibular disorders and the origin of otologic symptoms are not yet fully understood (FARELLA, MICHELOTTI, BOCCHINO et al., 2007). Some studies report that it may be related to poor positioning of the head of mandible, and the pressure produced by the displacement of the distal and posterior mandibular condyle over the auriculartemporal nerve and ear structures, especially on the auditory tube and the displacement of the head of mandible. This condition causes stretching of the ossicular chain, which can cause symptoms of otalgia, tinnitus and vertigo (NAKASHIMA, YANO, AKITA et al., 2007); in this context, Cone-beam CT has been useful to expose with details the area between ear and TMJ (Figure 2).

Clinical signs such as difficulty in opening the mouth, malocclusion, edema in the peripheral region of the ear and bone deformation may be considered predictors of unilateral or bilateral fracture of the head of mandible, and Cone-beam CT (Figure 3) has been indicated to demonstrate clearly this condition (RAUSTIA, PYHTINEN, OIKARINEN et al., 1990). In order to make the right choice of therapeutic approach to be performed, it is required the use of radiographic exams, such as panoramic radiography and computed tomography (ELLIS, PALMIERI and THROCKMORTON, 1999).

Occlusal problems are related to signs and symptoms of temporomandibular disorders and can affect chewing function and provide functional asymmetry of the stomatognathic system (MIYAWAKI, TANIMOTO,

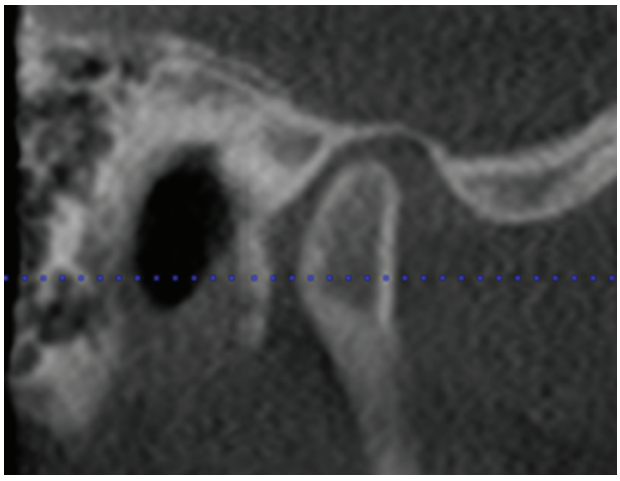

Figure 2. Incidence of right lateral Cone-beam tomography of the head of mandible.

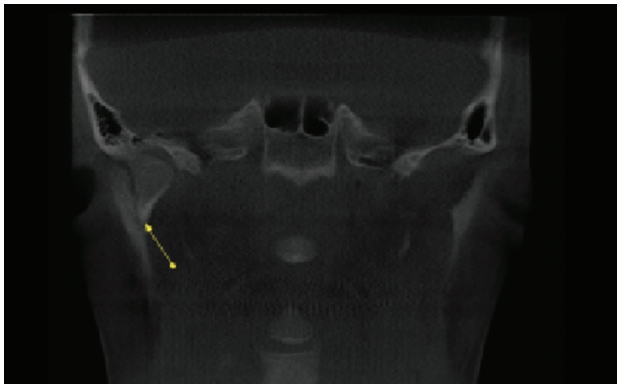

Figure 3. Tomographic imaging (Cone-beam) of the left mandibular head fracture (arrow).

ARAKI et al., 2004). The remodeling of the head of mandible occurs in patients with this disorder, characterized by mandibular displacement, leading to alteration of the form (MONGINI, 1981). Changes in TMJ can be found in situations where the malocclusion is present, and there is a possibility that it will become extensive (SOLBERG, BIBB, NORDSTROM et al., 1986).

3 Conclusions

Located in a region of great importance to the articulation with the skull and near the ear, the head of the mandible is a key structure, and its radiologic study is extremely necessary for clinical purposes. However, radiographic analysis by means of conventional methods, such as panoramic radiography, has a high degree of difficulty for the confirmation of local pathologies.

The Cone-beam CT allows three-dimensional visualization of the head of mandible with lower doses of radiation, and permits the removal of overlapping imaging. Thus, it has been effectively used in medical and dental clinics to aid in diagnosis and in therapeutic practice.

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References

AHLQVIST, JB. and ISBERG, AM. Validity of computed tomography in imaging thin walls of the temporal bone. *Dentomaxillofacial Radiology*, 1999, vol. 28, n. 1, p. 13-19. PMid:10202473. http://dx.doi.org/10.1038/sj.dmfr.4600398

ALOMAR, X., MEDRANO, J., CABRATOSA, J., CLAVERO, JA., LORENTE, M., SERRA, I., MONILL, JM. and SALVADOR, A. Anatomy of the temporomandibular joint. *Seminars in Ultrasound, CT and MRI*, 2007, vol. 28, n. 3, p. 170-183.

BJERKLIN, K. and ERICSON, S. How a computerized tomography examination changed the treatment plans of 80 children with retained and ectopically positioned maxillary canines. *Angle Orthodontist*, 2006, vol. 76, n. 1, p. 43-51. PMid:16448268.

BROOKS, SL. Computed tomography. *Dental Clinics of North America*, 1993, vol. 37, p. 575-590. PMid:8224334.

ELLIS, E.3rd, PALMIERI, C. and THROCKMORTON, G. Further displacement of condylar process fractures after closed treatment. *Journal of Oral and Maxillofacial Surgery*, 1999, vol. 57, n. 11, p. 1307-1316; discussion 1316-1307.

FARELLA, M., MICHELOTTI, A., BOCCHINO, T., CIMINO, R., LAINO, A. and STEENKS, MH. Effects of orthognathic surgery for class III malocclusion on signs and symptoms of temporomandibular disorders and on pressure pain thresholds of the jaw muscles. *International Journal of Oral and Maxillofacial Surgery*, 2007, vol. 36, n. 7, p. 583-587. Epub 2007 Mar 2026.

GARIB, DG., HENRIQUES, JF., JANSON, G., FREITAS, MR. and COELHO, RA. Rapid maxillary expansion--tooth tissue-borne versus tooth-borne expanders: a computed tomography evaluation of dentoskeletal effects. *Angle orthodontist*, 2005, vol. 75, n. 4, p. 548-557. PMid:16097223.

HATCHER, DC. and ABOUDARA, CL. Diagnosis goes digital. *American Journal of Orthodontics and Dentofacial Orthopedics*, 2004, vol. 125, n. 4, p. 512-515. PMid:15067269.

HUSSAIN, AM., PACKOTA, G., MAJOR, PW. and FLORES-MIR, C. Role of different imaging modalities in assessment of temporomandibular joint erosions and osteophytes: a systematic review. *Dentomaxillofacial Radiology*, 2008, vol. 37, n. 2, p. 63-71. PMid:18239033. http://dx.doi.org/10.1259/dmfr/16932758

LUDLOW, JB., DAVIES-LUDLOW, LE. and BROOKS, SL. Dosimetry of two extraoral direct digital imaging devices: NewTom cone beam CT and Orthophos Plus DS panoramic unit. *Dentomaxillofacial Radiology*, 2003, vol. 32, n. 4, p. 229-234. PMid:13679353. http://dx.doi.org/10.1259/dmfr/26310390

LUDLOW, JB., DAVIES-LUDLOW, LE., BROOKS, SL. and HOWERTON, WB. Dosimetry of 3 CBCT devices for oral and maxillofacial radiology: CB Mercuray, NewTom 3G and i-CAT. *Dentomaxillofacial Radiology*, 2006, vol. 35, n. 4, p. 219-226. PMid:16798915. http://dx.doi.org/10.1259/dmfr/14340323

MENG, F., LIU, Y., HU, K., ZHAO, Y., KONG, L. and ZHOU, S. A comparative study of the skeletal morphology of the temporomandibular joint of children and adults. *Journal of Postgraduate Medicine*, 2008, vol. 54, n. 3, p. 191-194. PMid:18626165. http://dx.doi.org/10.4103/0022-3859.40960

MERIDA-VELASCO, JR., RODRIGUEZ-VAZQUEZ, JF., MERIDA-VELASCO, JA., SANCHEZ-MONTESINOS, I., ESPIN-FERRA, J. and JIMENEZ-COLLADO, J. Development of the human temporomandibular joint. *Anatomical Record*, 1999, vol. 255, n. 1, p. 20-33. PMid:10321990.

MIYAWAKI, S., TANIMOTO, Y., ARAKI, Y., KATAYAMA, A., KUBOKI, T. and TAKANO-YAMAMOTO, T. Movement of the lateral and medial poles of the working condyle during mastication in patients with unilateral posterior crossbite. *American Journal of Orthodontics and Dentofacial Orthopedics*, 2004, vol. 126, n. 5, p. 549-554. PMid:15520687. http://dx.doi.org/10.1016/j.ajodo.2003.10.033

MONGINI, F. The importance of radiography in the diagnosis of TMJ dysfunctions. A comparative evaluation of transcranial radiographs and serial tomography. *Journal of Prosthetic Dentistry*, 1981, vol. 45, n. 2, p. 186-198. http://dx.doi.org/10.1016/0022-3913(81)90339-5

MOZZO, P., PROCACCI, C., TACCONI, A., MARTINI, PT. and ANDREIS, IA. A new volumetric CT machine for dental imaging based on the cone-beam technique: preliminary results. *European Radiology*, 1998, vol. 8, n. 9, p. 1558-1564. PMid:9866761. http://dx.doi.org/10.1007/s003300050586

NAKASHIMA, M., YANO, H., AKITA, S., TOKUNAGA, K., ANRAKU, K., TANAKA, K. and HIRANO, A. Traumatic unilateral temporomandibular joint dislocation overlooked for more than two decades. *Journal of Craniofacial Surgery*, 2007, vol. 18, n. 6, p. 1466-1470. PMid:17993903. http://dx.doi.org/10.1097/scs.0b013e31814fb5af

PARKS, ET. Computed tomography applications for dentistry. *Dental Clinics of North America*, 2000, vol. 44, n. 2, p. 371-394. PMid:10740774.

PIETTE, E. Anatomy of the human temporomandibular joint. An updated comprehensive review. *Acta Stomatologica Belgica*, 1993, vol. 90, n. 2, p. 103-127. PMid:8237635.

RAUSTIA, AM., PYHTINEN, J., OIKARINEN, KS. and ALTONEN, M. Conventional radiographic and computed tomographic findings in cases of fracture of the mandibular condylar process. *Journal of Oral and Maxillofacial Surgery*, 1990, vol. 48, n. 12, p. 1258-1262; discussion 1263-1254.

SCARFE, WC., FARMAN, AG. and SUKOVIC, P. Clinical applications of cone-beam computed tomography in dental practice. *Journal of the Canadian Dental Association*, 2006, vol. 72, n. 1, p. 75-80. PMid:16480609.

SCHULZE, D., HEILAND, M., THURMANN, H. and ADAM, G. Radiation exposure during midfacial imaging using 4- and 16-slice computed tomography, cone beam computed tomography systems and conventional radiography. *Dentomaxillofacial Radiology*, 2004, vol. 33, n. 2, p. 83-86. PMid:15313998. http://dx.doi.org/10.1259/dmfr/28403350

SOLBERG, WK., BIBB, CA., NORDSTROM, BB. and HANSSON, TL. Malocclusion associated with temporomandibular joint changes in young adults at autopsy. *American Journal of Orthodontics*, 1986, vol. 89, n. 4, p. 326-330. http://dx.doi.org/10.1016/0002-9416(86)90055-2

UTUMI, ER., OLIVEIRA SALES, MA., SHINOHARA, EH., TAKAHASHI, A., CORACIN, FL., ROCHA, RG. and PARAISO CAVALCANTI, MG. SAPHO syndrome with temporomandibular joint ankylosis: clinical, radiological, histopathological, and therapeutical correlations. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology & Endodontics*, 2008, vol. 105, n. 3, p. e67-72. PMid:18280950.

WHITE, SC. Cone-beam imaging in dentistry. *Health Physics*, 2008, vol. 95, n. 5, p. 628-637. PMid:18849696. http://dx.doi.org/10.1097/01.HP.0000326340.81581.1a

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