BENNETT MOVEMENT OF MANDIBLE: A COMPARISON BETWEEN TRADITIONAL METHODS AND A 64-SLICES CT SCANNER

E. FANUCCI, E. SPERA*, L. OTTRIA*, A. BARLATTANI Jr.*, N. FUSCO, I. MYLONAKOU, P. BROCCOLI, A. BARLATTANI*, G. SIMONETTI

University of Rome "Tor Vergata", Rome, Italy
Department of Diagnostic and Molecular Imaging, Interventional Radiology and Radiotherapy
** Department of Odontostomatological Sciences*

SUMMARY

Bennett movement of mandible: a comparison between traditional methods and a 64-slices CT scanner

Objective: compare the values of the Bennett angle measured by an average value articulator with the ones measured by a 64 slices Computed Tomography (CT).
Methods: we have studied a patient aged 72. Maxillary and mandibular impressions were obtained from the patient and placed on the average value articulator using wax-ups and a facial arch in order to perform the Bennett angle measurations by such device. CT measurements were carried out using templates in order to block the Patient in the correct mandibular position.
Results: our study has demonstrated that the measurements of the Bennett angle obtained with the average value articulator are consistent with the ones obtained with the 64 slices CT.
Conclusions: CT scanning is a useful method, alternative to conventional procedures, as the average value articulator for Bennett angle measurements, and it could become an important diagnostic tool in the gnathological and rehabilitative area.

Key words: temporomandibular joint, Bennett angle, computed tomography, articulator.

RIASSUNTO

Il movimento mandibolare di Bennett: comparazione tra sistemi tradizionali di registrazione e TC a 64 strati

Scopo: comparare i valori dell'angolo di Bennett misurato tramite un articolatore a valori medi e con TC a 64 strati.
Metodo: abbiamo esaminato un uomo di 72 anni. Le impronte delle arcate mascellari e mandibolari sono state rilevate e posizionate su un articolato a valori medi tramite l'uso di cere e di un arco facciale al fine di effettuare la misurazione dell'angolo di Bennett. Le misurazioni con l'esame TC sono state eseguite con l'utilizzo di mascherine per bloccare il paziente nella corretta posizione mandibolare.
Risultati: il nostro studio ha dimostrato che le misurazioni dell'angolo di Bennett ottenute tramite un articolatore a valori medi sono quasi sovrapponibili con quelle ottenute con la TC a 64 strati.
Conclusioni: la TC è una metodica utile ed alternativa alle procedure convenzionali, quale l'articolatore a valori medi, per la misurazione dell'angolo di Bennett e potrebbe divenire un importante strumento diagnostico in campo riabilitativo e gnatologico.

Parole chiave: articolazione temporo-mandibolare, angolo di Bennett, tomografia computerizzata, articolatore.

Introduction

Mandibular kinetics is made up of complex movements in addition to the opening and closing movements of the jaw: they take place on the sagittal plane, on the vertical plane and on the transverse plane (1). The Bennett movement is part of this group of movements (2-3). It is a complex lateral movement or lateral shift of the mandible resulting from the movements of the condyles along the lateral inclines of the mandibular fossae during lateral jaw movement. The Bennett movement can be studied in detail by a technique called "pantographic registration", which shows that it consists of two movements: the immediate Bennett side-shift which occurs at the beginning of the translation, and the progressive Bennett side shift. In the immediate Bennett side shift, the orbiting condyle moves essentially straight medially as it leaves centric relation at the beginning of the lateral jaw movement, while the progressive Bennett side shift creates an angle (the Bennett angle) formed by the sagittal plane and the path of the advancing condyle during lateral mandibular movement as viewed in the horizontal plane (Fig. 1).

The Bennett angle is the anatomic morphology of the medial wall of the glenoid cavity, and, by obtaining central and lateral wax-ups (which correspond to the beginning and end of the condylar shift or movement) it is possible to transfer data from an average value articulator by measuring the angle in degrees (4).

In an occlusal rehabilitation, the Bennett angle has a very high gnathological importance since its presence and size affect the occlusal relationships of denture fabrication (5). Indeed, Bennett's angle and movement are directly proportional to the side lateral shift; and, from the analysis of effects that they have on occlusal morphology we infer, for example, that the bigger is the side lateral shift, the more distal will be the working and balancing sulcus in the superior teeth, the lower will be the cuspis of the posterior teeth and the greater will be the concavity of the anterior teeth (*over jet*). On the contrary, the smaller is the side lateral shift, the higher may be the cuspis of the posterior teeth.

Therefore, there is a close relationship between the pattern of Bennett's movement and the anatomy of the teeth since, during the movement, the cuspis must not interfere with the antagonist ones but must move through some well identified ways of escape which are actually sulcus and cuspis.

All the above confirms the great importance of the registration and the clinical evaluation of the mentioned angle.

The computed tomography has been already used in the evaluation of the Bennett angle (6, 7); however, its application has been only used for the measuration of the angle without any other clinical use. The new 64 slices CT scanners, ensuring the acquisition of slices' thickness of 0.6 mm, grant a more detailed evaluation of the temporomandibular joint surfaces and allow new horizons in the anatomical-functional studies (8).

The present work intends to verify the reliability of the traditional measuration methods considering the possibility of using such methods along with other newer and more effective methods based on the multislices CT scanners.

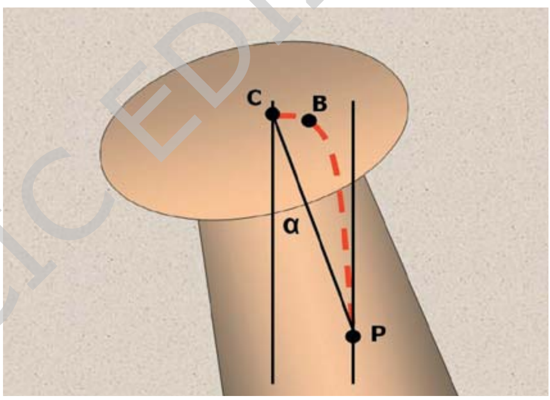

Figure 1
Condyle movement on non-working side (NWS) during Bennett movement: C = center of rotation; CB = immediate Bennett side shift; BP = progressive Bennett side shift; α = Bennett angle.

Material and methods

In this study, our subject was a 72 year-old man who did not have any problems with his dental formula and occlusion.

A molded impression of the maxillary and mandibular teeth was taken along with the lateral and central wax-ups (Figg. 2, 3, 4).

With central relationship is meant maxillo-mandibular relationship in which condyles are lo-

Figure 2
Maxillary dental impression.

Figure 3
Mandibular dental impression.

Figure 4
Left/right lateral and central wax-ups.

cated very close to the articular disc; such relationship becomes terminal and acquires the name of Reference Position (RP) when the condyles are located in the highest and more central position but not in the one necessarily most retrusal.
Then, we have placed a transfer facial arch to allow the registration of the inclination of the superior maxillary bone in respect of the orbital axis level.
The plaster models have then been applied thanks to wax-ups and facial arch on an average value articulator SAM® (Fig. 5) on which we have done the Bennett angle measuration afterwards.
Transparent templates in acrylic material were developed using the gypsum models.
The templates have been constructed in one block being the superior part in contact with the superior maxilla and the inferior part with the mandibula in order to block the Patient in the correct and stable mandibular position during the CT acquisition. The positions that we have studied by means

Figure 5
Average Value Articulator (SAM®).

of CT scanning were kept fixed by the use of the templates. The centric relation, the right laterality (Fig. 6) and the left laterality were determined. Three volumetric scans were performed from the inferior margin of the jaw to the apex, with the templates placed in succession. The exams have been acquired using a Volumetric 64 slices CT (Light Speed VCT, General Electric, Medical Systems, USA). The acquisition technique consisted of a preliminary antero-posterior (AP) scan and latero-lateral (LL) scan; with the following parameters of acquisition: 80 kV and 20 mA.
The following acquisitions have been acquired with a thickness of 0.6 mm, a 0.4-milimeter interval, rotation time of 0.5 s, 150 mA, 120 Kv, 15 cm FOV, 512x512 womb with an angle-shot of the gantry of 0°.
It is of extreme importance to maintain the patient in the same position during the acquisitions to allow a reliable comparison of the data obtained with the three different positions. In our clinical setting this has been possible by using two external references consisting of a drop of a CT visible gel positioned on the median sagittal line of the forehead and on the right zygomatic process of the patient. By using the CT localization laser it has been possible to have the same patient positioning during the entire examination. In the first scan it has been examined the entire skull.

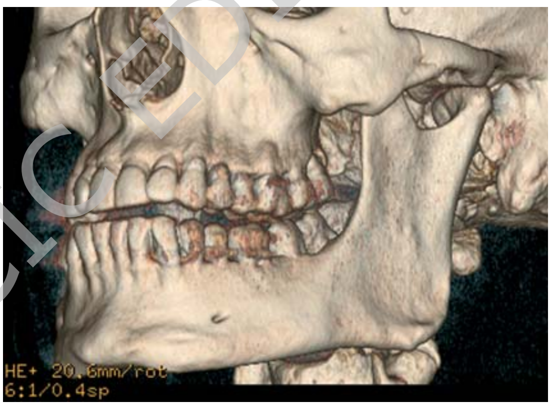

Figure 6
3D reconstruction performed with templates positioned laterally on the right side.

In the second and the third scan the skull has been examined from the zygomatic arch to the angle of the jaw.
The images obtained have been elaborated and reconstructed through Mimics software® of the Materialize® (Fig. 7).
The acquisition parameters have been chosen are a good compromise between the anatomical information and the dose (9).
An informed consent to the study was obtained from the Patient.

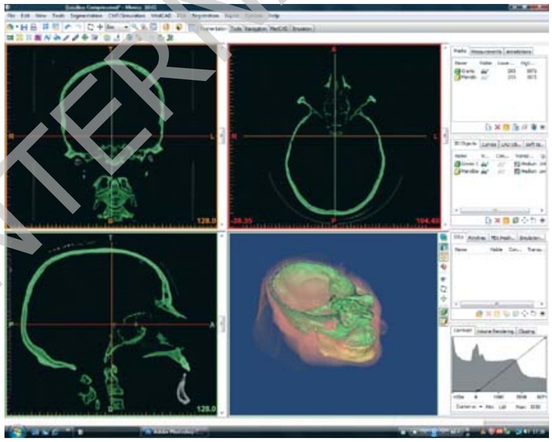

Figure 7
Mimics® software screen image displaying a 3D reconstruction.

Results

The 0.6 mm slice thickness used for all the acquisitions allowed us to obtain high definition three-dimensional images.
For the correct measurement of the lateral and the centric occlusion condyles shift, it is necessary to identify the geometric center of the condyles. This has been obtained by drawing around the largest visible portion of the condyles two quadrilaters having their sides tangent to the external margins of the condyles themselves (Fig. 8). The geometric centre of the condyles was defined as the crossing point between the two diagonals of the quadrilaters.

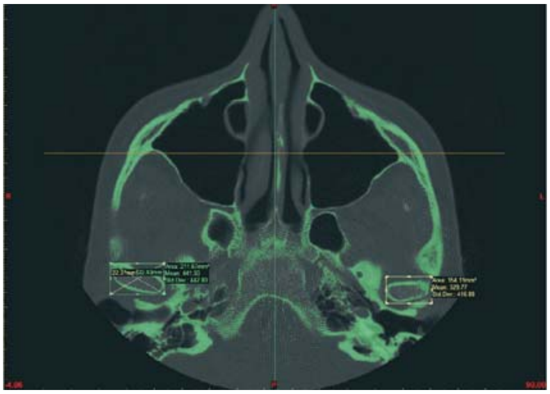

Figure 8
Quadrilaters used to perform the measurements (centric position).

Later on, the areas of the quadrilaters were calculated in all the three different positions and also the respective geometrical centres of the condyles. The condyles shifts were calculated by comparing on a single image the condyles' geometrical centres obtained in the three different positions. Bennett angle was defined as the angle formed by the spatial coordinates of the condyles shifts and the sagittal plane (Fig. 9).
The Bennett angle measured with the articulator to medium was 24° (medium value), wheareas

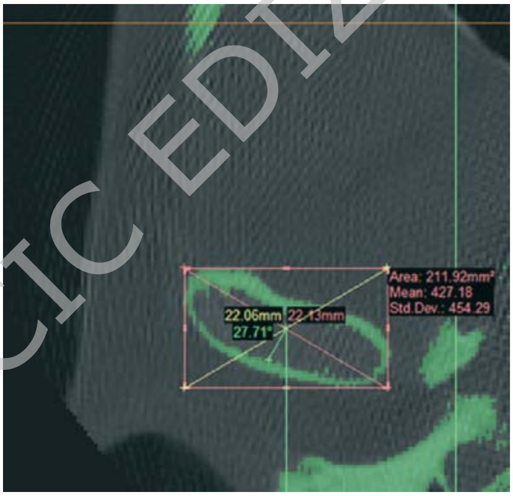

Figure 9
Angle determined on the basis of the geometric centres shifts.

27.71° was its value when CT imaging was used for the calculations.

Discussion

Nowadays, the technological development that the Diagnostic Imaging has had during the last few years and, in particular, the computed tomography allows us to benefit from measurement methods of absolute precision being able to perform morphological and highly detailed studies. The measurement *"in vivo"* of a parameter such as the Bennett angle is greatly important for a right protesical and gnathological rehabilitation. Furthermore, CT volumetric acquisition always gives complete information relating to the bony and dental structures of the masticatory apparatus (10), allowing also to perform Dentalscan reconstructions, multiplanar and endoscopical virtual navigations in the paranasal sinus.
The difference in the measurations of the angle using the average value articulator and the computed tomography could be caused by the highly sensitiveness of CT analysis and by the different tissues resistance.
In conclusion, the possibility of obtaining the detailed morphology of bone and dental structures, and extracting measurements that are important to the rehabilitation, such as the angle of Bennett indeed, opens new future perspectives regarding the use of this data at odontotechnical laboratory.
The use of purely mechanistic systems can probably be consecutively assisted or replaced by applications of diagnostic imaging and all this is not that distant in time taking into consideration the quick evolution of the technologies CAD-CAM and their actual applications in dentistry.

References

1. Koolstra JH. Dynamics of the human masticatory system. Crit Rev Oral Biol Med 2002; 13 (4): 366-376.

2. Stiesch-Scholz M, Demling A. Rossbach Reproducibility of join movements in patients with craniomandibular disorders. Journal of Oral Rehabilitation 2006; Vol 33, 11: 807.
3. Lundeen HC, Gibbs CH. Advances in occlusion, 1:9, John Wright, PSG, Inc, Boston 3. Gibbs CH, Masserman: "Functional movements of the mandible". J Prost Dent 1971; 26: 601.
4. Heinz Höhne K, Bomans M, Tiede ULF, Riemer M. Display of multiple 3D-objects using the generalized voxel-model. In R.H. Schneider, S.J. Dwyer (eds.): Medical Imaging II, Part B, Proc. SPIES 914. Newport Beach 1988; 850-854.
5. Lundeen H. Introduction to the anatomy occluded them. editions Martina 2004.
6. Villa Vigil BUT, Alvarez Arenal To, Rodriguez Gonzalez BUT, Of the Field Oliver To, Costilla Garcia S, Gomez Martinez JL. To method for studying the Bennet angle using computerized axial tomography. Rev Eur Odontostomatol. 1989 Jul-Aug; 1 (4): 233-8.
7. Tsiklakis K, Syriopoulos K, Stamatakis HC. Joint Radiographic examination of the temporomandibular using cone beam computed tomography. Dentomaxillofacial Radiol 2004 May; 33 (3): 196-201.
8. Garvey CJ, Hanlon R. Computed tomography in clinical practice, BMJ 2002; 324: 1077-80.
9. Brix G, Nagel HD, Stamm G, Veit R, Lechel U, Griebel J, Galanski M. Radiation exposure in single-slice fines-slice versus spiral CT: results of to nationwide survey. European Radiology 2003; 13 (8): 1979-1991.
10. Sommer OR, Aigner F, Rudisch TO, Gruber H, Fritsch H, Millesi W, Stiskal M. oint Cross-sectional and functional imaging of the temporomandibular:radiology, pathology and basic biomechanics of the jaw, Radiographics 2003; 23: e14.

Correspondence:
Prof. Ezio Fanucci
Department of Diagnostic and Molecular Imaging,
Interventional Radiology and Radiotherpy
University of Rome "Tor Vergata", Rome, Italy
Viale Oxford, 81 - 00133 Rome
Tel.: 0620902374 - Fax: 0620902404
E-mail: ezio.fanucci@libero.it