UNIVERSIDAD DE OVIEDO
MASTER UNIVERSITARIO DE ORTODONCIA Y ORTODPEDIA DENTOFACIAL

RELACIÓN RADÍCULOCORTICAL DEL INCISIVO INFERIOR EN LOS DIFERENTES TIPOS FACIALES. UN ESTUDIO EN CBCT.

Áurea Ortega Peire

Trabajo Fin de Master
8 de Mayo de 2013

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" Evaluation of mandibular incisor bony support. A comparative study between lateral cephalometric radiograph and CBCT "

Objective : The aim of our study is to compare the results obtained from the quantitative evaluation of mandibular alveolar bone, using lateral cephalometric radiograph and cone-beam computed tomography. **Materials and Methods :** The sample consited of 4 patients with natural dentition. Lateral cephalometric radiograph and cone-beam computed tomography (CBCT) were obtained from each patient. Bony support of the most protruded lower incisor was measured on the radiograp. Bony support was also measured at the 4 mandibular incisors on CBCT. **Results :** Most measurements obtained were higher on the lateral cephalometric radiograph than on cone-bean computed tomography. The most significant difference obtained was the height of the mandibular symphysis, and we also should note the vestibular part of cancellous bone. Differences were also found when comparing the 4 incisors in CBCT. **Conclusions** : From the results obtained in our study, we can conclude that the information supplied by the lateral cephalometric radiograph is incomplete, as it is based in one only incisor, normally the most protruded, whose bony support is not usually of the same quantity and quality as the rest of the incisors. In our study, bony support is greater at central mandibular incisors than at lateral mandibular incisors.Therefore, we should stop considering the lower incisor shown on the lateral cephalometric radiograph as the reference focus for treatmen planning. As a diagnostic tool, CBCT proves to be more precise and accurate than lateral cephalometric radiograph, when analizying the bony support of lower incisors.

"Bone traces tooth movement" is a basic postulate in Orthodontics, implying that whenever tooth movement occurs, remodeling of the bone around the alveolar socket will take place to the same extent. Since bone resorption takes place in the direction of tooth movement, the reduced volume of alveolar bone, sometimes minimal or even nonexistent, is a common complication in orthodontic treatment.[1]

Although some bone loss and root resorption is accepted in adult patients, when exceeding certain limits, dentition may be compromised. When the teeth are repositioned in their anatomical limits, that is, within the alveolar bone, the iatrogenic effects are reduced. It is important to draw the limits of orthodontic treatment in adult nongrowing patients.

The position and movement of the lower incisors plays an important role in diagnosis and treatment planning. The relationship of the apex with the vestibular and lingual cortical plates determine the limits of tooth movement. This will often be the key to deciding whether the treatment will require extractions, will be merely orthodontic or will need to be complemented with orthognatic surgery. [2]

The attempt to identify an "orthodontically" ideal and stable position of the lower incisors, which will not cause periodontal problems and crowding relapse, has led us to determine their utmost anterior limit.

The incisor is properly positioned when situated in the medullary portion of the alveolar bone. The mandibular symphysis is considered to be the anatomic factor which limits the movements of lower incisors. [3,4]

In this area, the alveolar process is buccolingually narrow, which implies that lower incisors are supported by a thin bony layer. Sometimes extens tooth movements are required in order to achieve treatment goals. Other times, routine orthodontic tooth movement may take the tooth root out of the center of the alveolar bone, causing alveolar defects, root resorption and gingival recession. This will depend on the initial morphology of the alveolar bone and the amount of tooth movement involved.[1,4,5]

Thus, it is essential to know the anatomy of the symphysis, the amount of bony support and the integrity of periodontal tissues.

The previous attempts to measure alveolar bone have resulted in complicated methods, often time-consuming to perform and generating variable estimations.

Currently, cone-beam computed tomography (CBCT) is the option chosen to measure alveolar bone owing to its low level of radiation, better image resolution and low cost when compared with conventional computed tomography (CT). The former enables more accurate examination of the alveolar bone without the disadvantages of conventional radiographs. The images obtained, in addition to being 3D, are not subject to distortion or superimposition and secondary computerized reconstructions facilitate quantitative as well as qualitative evaluation of bone surfaces, quantitative evaluation of the relationship between teeth and bone, and selection of the desired sections. Moreover, immediate results are obtained. [1,-8,9,10,11,15]

Therefore, on considering its advantages, we chose CBCT to evaluate the mandibular bone support.

OBJECTIVES

The aim of our study is to compare the results obtained from the quantitative evaluation of mandibular alveolar bone, using lateral cephalometric radiograph and CBCT.

MATERIALS AND METHODS

The sample consisted of 4 adult patients with natural dentition.
Patients were students of the Faculty of Dentistry of Seville.

Lateral cephalometric radiograph and cone-beam computed tomography (CBCT) images of the patients were obtained and analyzed.

Based on Uysal´s study, the following parameters were measured, in the most protruded lower incisor, on lateral cephalometric radiograph, and in sections that corresponded to the four lower incisors, on CBCT (*Fig 1*):

(1) Height of the mandibular symphysis.
(2) Cancellous bone height of the mandibular symphysis.
(3) Thickness of the mandibular symphysis.
(4) Cancellous bone thickness of the mandibular symphysis.

We subsequently divided the cancellous bone thickness into vestibular and lingual portions.

All landmarks used in this study are given and defined in *Table 1*.

In CBCT, the sagital slices were arranged so that the vertical reference line on the panoramic view would pass through the central axis of the incisors. In the lateral cephalometric radiograph, we considered the central axis of the incisor.

To improve the quality of the radiograph and define the points that had to be evaluated more precisely, we tried radiograph in Adobe Photoshop, and by adjusting black and white chroma levels, we obtained a sharper and more accurate image. This image was imported into AutoCAD 2008 program, which reined the different measurements of our study.

In both cases, all measurements were taken by drawing lines perpendicular and parallel to the central axis of the incisor.

Table 1. Landmarks used in the study
A point : the point of the internal surface of the anterior cortex.
P point : the point of the internal surface of the posterior cortex.
As point: the most anterosuperior point of the mandibular alveolar process.
Lc point: the point formed by the intersection of external surface of the lingual cortex and the line parallel to the axis of the incisors anda crossing the As point.
Center of rotation (C): the midpoint of the incisor root position embedded in alveolar bone.
L point : the apex of the root.
CH line: the line paralell to the axis of the incisor from the vestibular to the lingual cortex of the symphysis
MT line: the line perpendicular to the axis of the incisors that passes trough the apex of the root between the external surfaces of the lingual and vestibular cortex.
A-P size: the points between points A and P that corresponds to the cancellous bone thickness of the alveolar process.
A-L size: the arc between points A and L taht identifies the vestibular portion of cancellous bone of the symphysis.
L-P size: the arc between points L and P that identifies the lingual portion of cancellous bone of the symphysis.

To avoid potential errors associated with the measurements, these were repeated two weeks later by the same observer. No significative differences were found between the first and second measurement.

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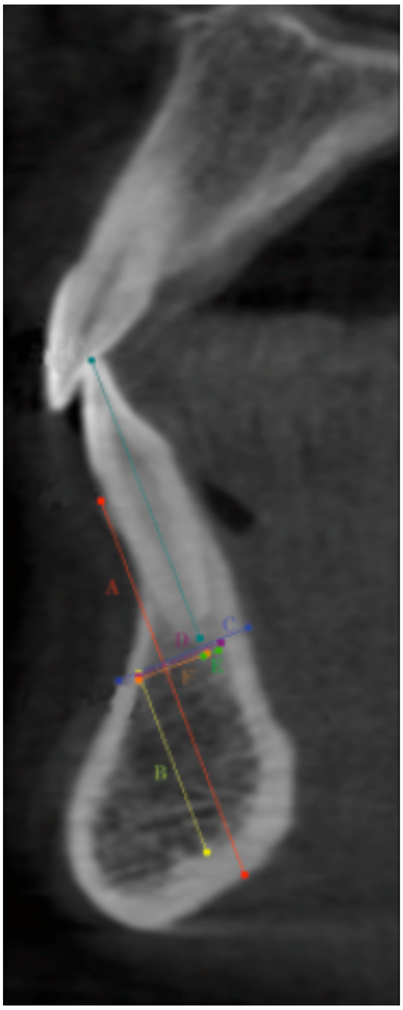

Fig1: *A*, Heigh of mandibular symphysis (*As point to Lc point*); *B*, cancellous bone height of mandibular symphysis (*CH line*); *C*, thickness of mandibular symphysis (*MT line*); *D*, cancellous bone thickness of mandibular symphysis (*A point to P point*); *E*, vestibular cancellous bone thickness (*A point to L point*); *F*, lingual cancellous bone thickness (*L point to P point*).

RESULTS

Two tables were performed per patient, one corresponding to the lateral cephalometric radiograph and the other to CBCT.

Figures 2-3, and tables 2-3 correspond to the first patient. The measurement values obtained were slightly higher in the lateral cephalometric radiograph than in CBCT. In this respect, the most notable is the height of the mandibular symphysis and the vestibular part of cancellous bone. Furthermore, in the CBCT we found differences between the different incisors. The most significant was the height of the symphysis at the left lateral incisor (23.9 mm versus 29.7 mm, 30.9 mm and 29.4 mm of other incisors). The height of the symphysis at lateral incisors is less than at central incisors.

Figures 4 -5, and Tables 4-5 belong to the second patient. In this case, measurements obtained were also higher on the radiograph than in the CBCT, except for the lingual part of cancellous bone. The thickness of the symphysis, the cancellous bone height and the vestibular part of cancellous bone should be noted. On CBCT we found two important differences between the incisors: the cancellous bone height of the lower right lateral incisor was significantly lower than that of the other incisor (7,6 mm compared with 9,5 mm and 8,8 mm with10,3 mm).

Patient three is described in figures 6-7 and tables 6 -7. Measurements obtained are once again higher on radiograph than on CBCT. The vestibular part of cancellous bone is the most significant difference that we found. However, as in the case of patient 2, the lingual part of cancellous bone is smaller on the radiograph than on CBCT. When comparing the 4 incisors on CBCT, the cancellous bone height at lateral incisors was significantly less than at the central incisors.

The fourth patient is analyzed and described in figures and tables 8-9.

Once again, the measurements obtained from the cephalometric analysis, are higher than on the CBCT, except for the cancellous bone height at the lower right central incisor and the lingual part of cancellous bone. When comparing the 4 incisors on CBCT, there is a significant decrease in the height of the symphysis at the lower right lateral incisor.

At the same time, thickness of the mandibular symphysis is higher in that incisor. Lateral incisors have less height and width of supporting bone with an exception: the vestibular part of cancellous bone.

Measurements (mm)	31	32	41	42
Height of the mandibular symphysis	29,7	23,9	30,9	29,4
Cancellous bone height	14,2	13,5	14,3	13,5
Thickness of the mandibular symphysis	10,5	10,4	10	9,9
Cancellous bone thickness	6,9	6,1	5,6	5,6
Vestibular part of cancellous bone	6,5	4,9	4,8	3,5
Lingual part of cancellous bone	1,1	1,2	1,7	2,1

Table 2: Measurements obtained in patient 1 on CBCT

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Measurements (mm)	Incisivo
Height of the mandibular symphysis	30,5
Cancellous bone height	14,1
Thickness of the mandibular symphysis	11,5
Cancellous bone thickness	7,1
Vestibular part of cancellous bone	5,8
Lingual part of cancellous bone	1,3

Table 3: Measurements obtained in patient 1 on lateral cephalometric radiografh

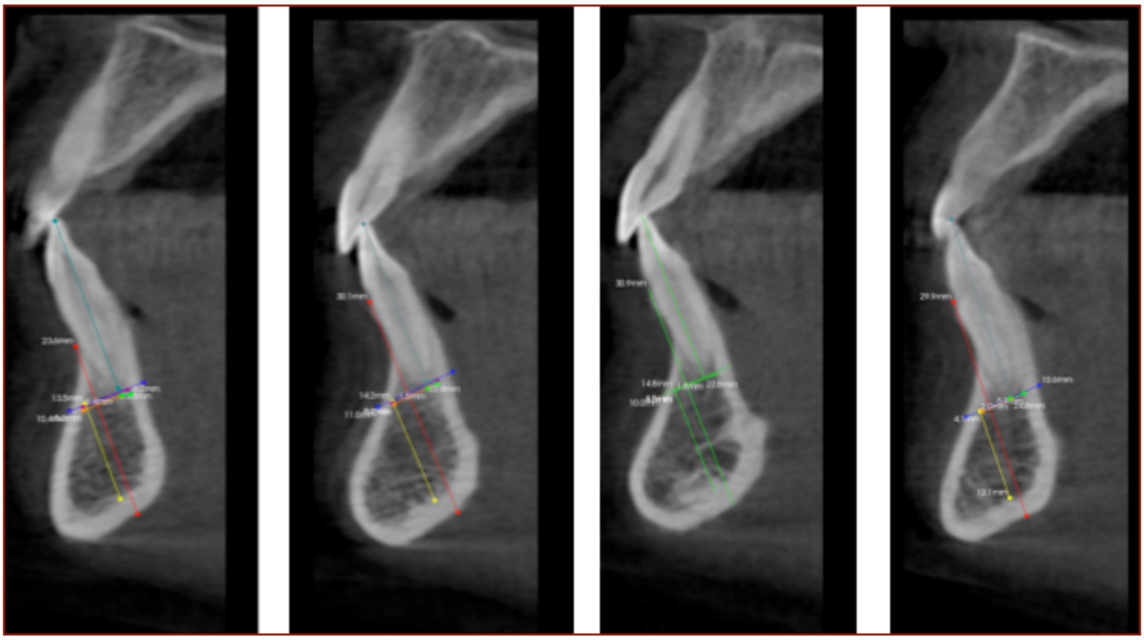

Figure 2 :CBCT sagittal sections from patient 1.
Incisors 32, 31, 41 and 42.

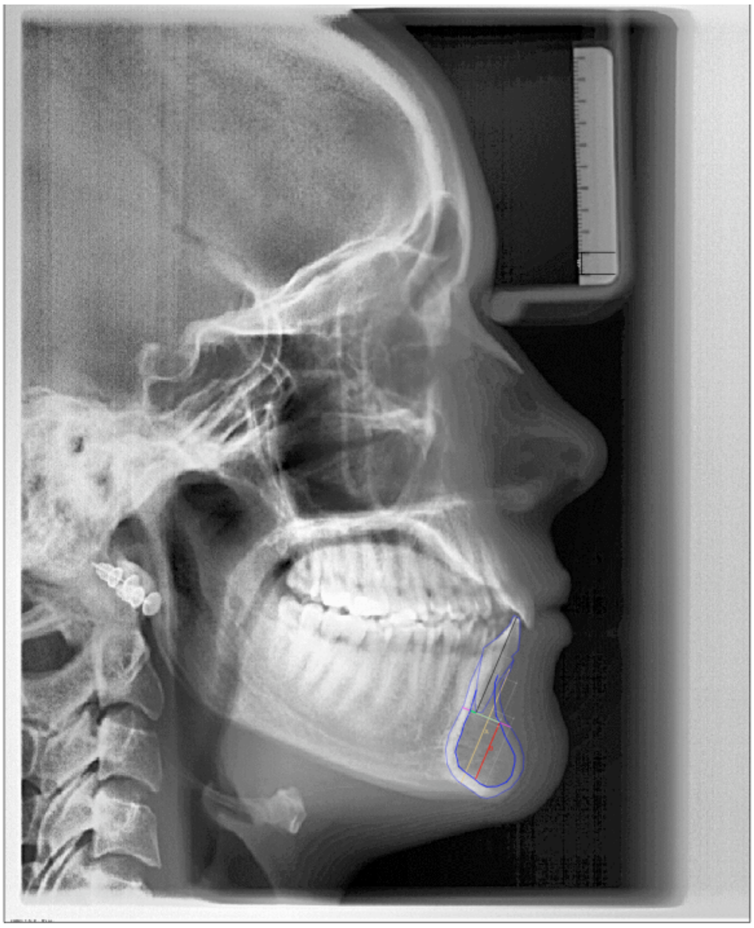

Figure 3: Lateral cephalometric radiograph from patient 1

Measurements (mm)	31	32	41	42
Height of the mandibular symphysis	26,5	27,2	26,8	26,7
Cancellous bone heigth	9,5	8,8	10,3	7,6
Thickness of the mandibular symphysis	8,9	8,3	8,8	6,7
Cancellous bone thickness	5,3	4,3	5,6	4,7
Vestibular part of cancellous bone	4,4	3,4	3,8	3,6
Lingual part of cancellous bone	0,9	0,9	1,8	1,1

Table 4: Measurements obtained in patient 2 on CBCT.

Measurements (mm)	Incisivo
Height of the mandibular symphysis	26,1
Cancellous bone height	11,2
Thickness of the mandibular symphysis	9,5
Cancellous bone thickness	5,8
Vestibular part of cancellous bone	5,1
Lingual part of cancellous bone	0,7

Table 5: Measurements obtained in patient 2 on lateral cephalometric radiograph.

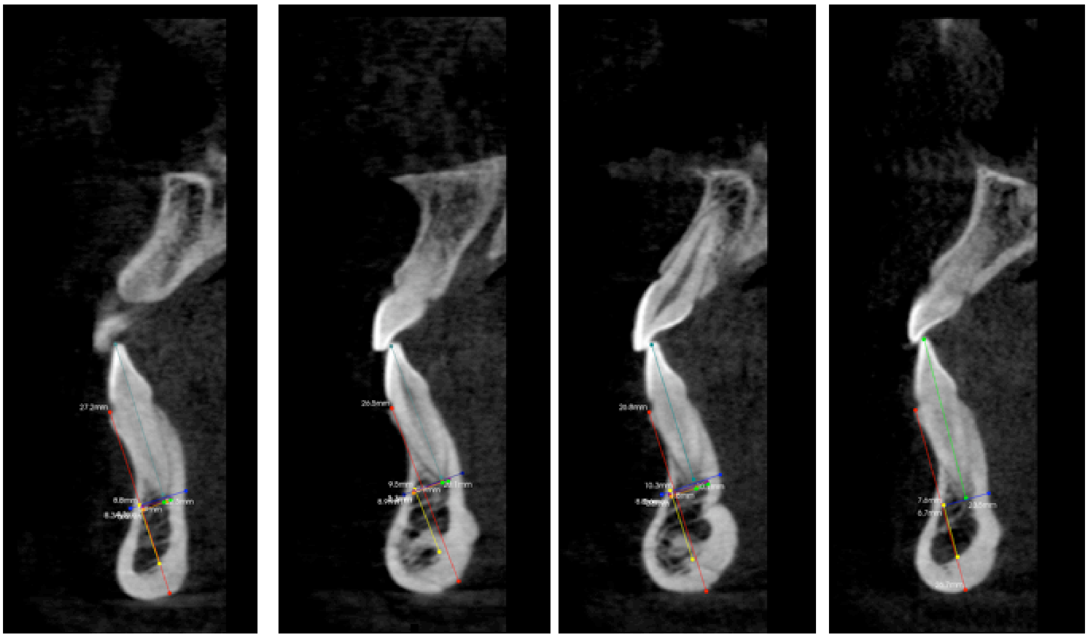

Figure 4: CBCT sagittal sections from patient 2.
Incisors 32, 31, 41 and 42.

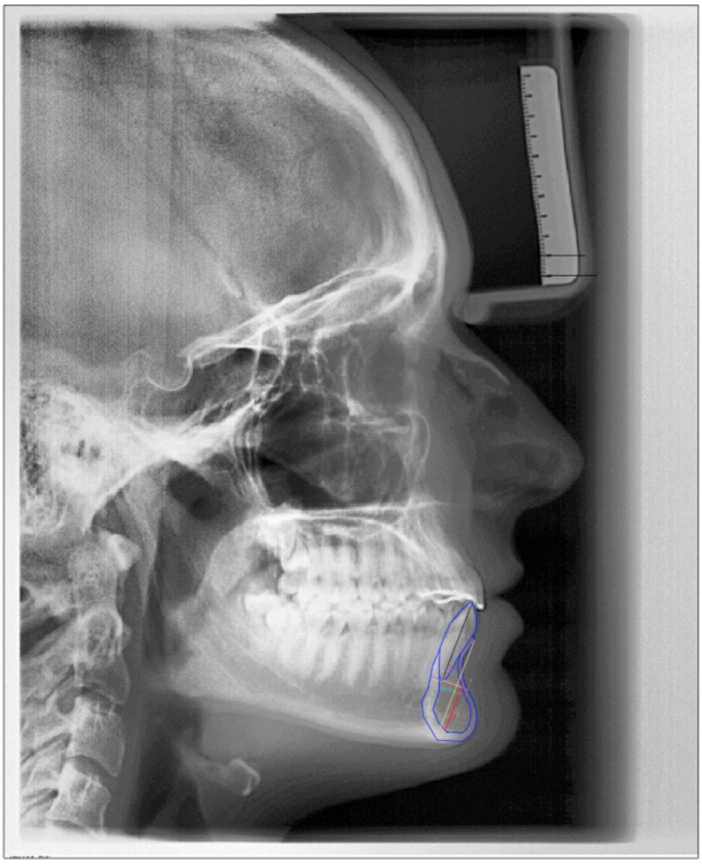

Figure 5: Lateral cephalometric radiograph from patient 2

Measurements (mm)	*31*	*32*	*41*	*42*
Height of the mandibular symphysis	24,4	26,0	25,1	24,5
Cancellous bone heigth	14,5	12,9	14,2	10,7
Thickness of the mandibular symphysis	8,4	9,0	8,2	8,2
Cancellous bone thickness	4,6	4,7	4,3	4,1
Vestibular part of cancellous bone	2,4	2,5	2,0	2,5
Lingual part of cancellous bone	2,2	2,2	2,3	1,6

Table 6: Measurements obtained in patient 3 on CBCT

Measurements (mm)	**Incisivo**
Height of the mandibular symphysis	27,5
Cancellous bone heigth	13,0
Thickness of the mandibular symphysis	9,3
Cancellous bone thickness	5,8
Vestibular part of cancellous bone	4,8
Lingual part of cancellous bone	1,0

Table 7 : Measurements obtained in patient 3 on lateral cephalometric radiograph

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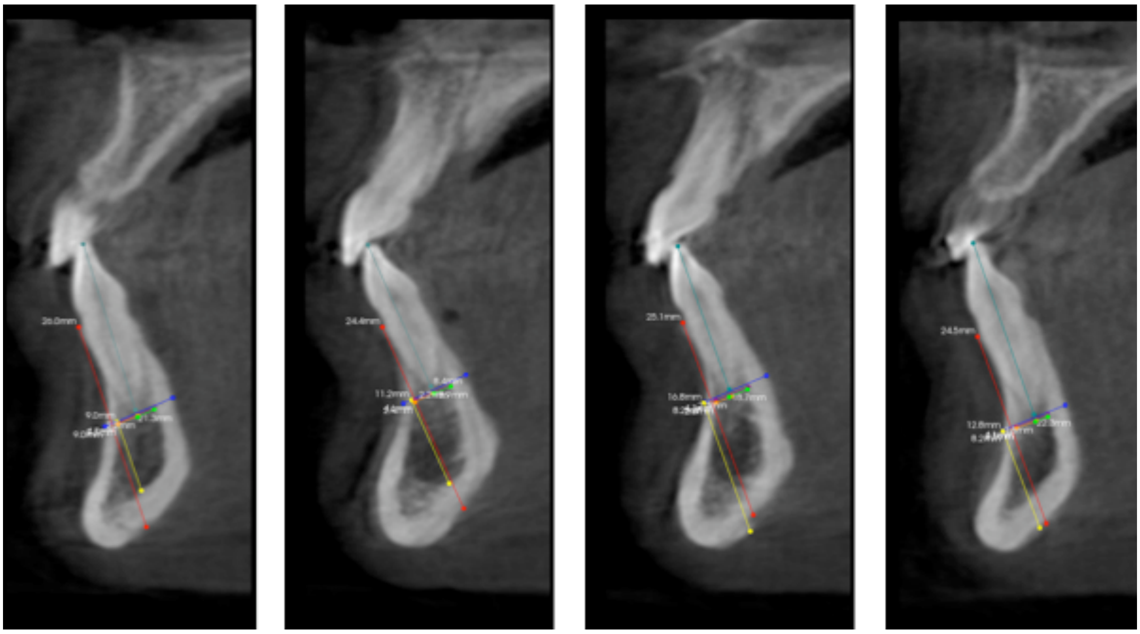

Figure 6: CBCT sagittal sections from patient 3.
Incisors 32, 31, 41 and 42.

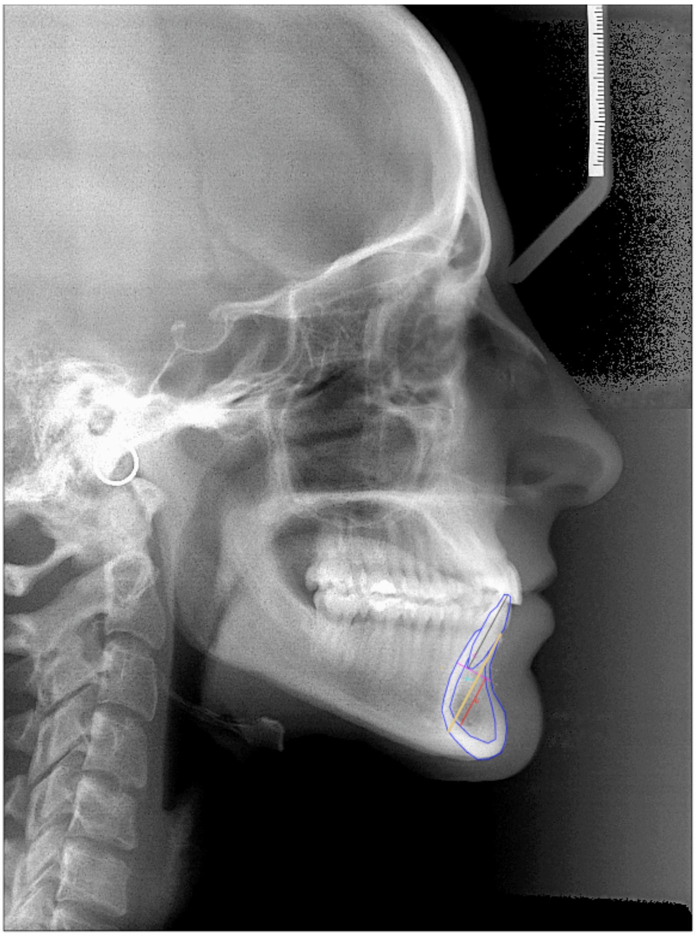

Figure 7: Lateral cephalometric radiograph from patient 3

Measurements (mm)	31	32	41	42
Height of the mandibular symphysis	24,5	23,0	23,6	19,2
Cancellous bone heigth	9,8	8,4	13,5	10,2
Thickness of the mandibular symphysis	11,6	11,2	11,8	13,2
Cancellous bone thickness	7,4	6,7	7,0	7,4
Vestibular part of cancellous bone	4,4	5,5	4,5	5,4
Lingual part of cancellous bone	2,8	1,2	2,5	2,0

Table 8: Measurements obtained in patient 4 on CBCT.

Measurements (mm)	**Incisivo**
Height of the mandibular symphysis	24,4
Cancellous bone heigth	10,5
Thickness of the mandibular symphysis	13,5
Cancellous bone thickness	9,5
Vestibular part of cancellous bone	7,8
Lingual part of cancellous bone	1,7

Table 9: Measurements obtained in patient 4 on lateral cephalometric radiograph

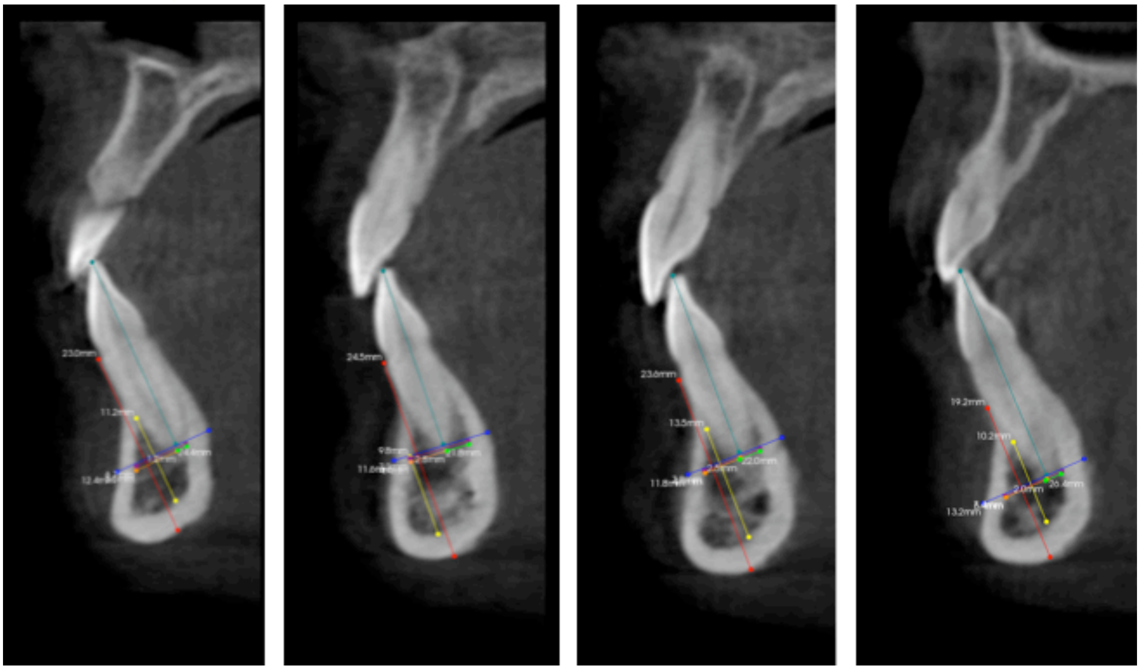

Figure 8: CBCT sagittal sections from patient 4
Incisors 32, 31, 41 and 42.

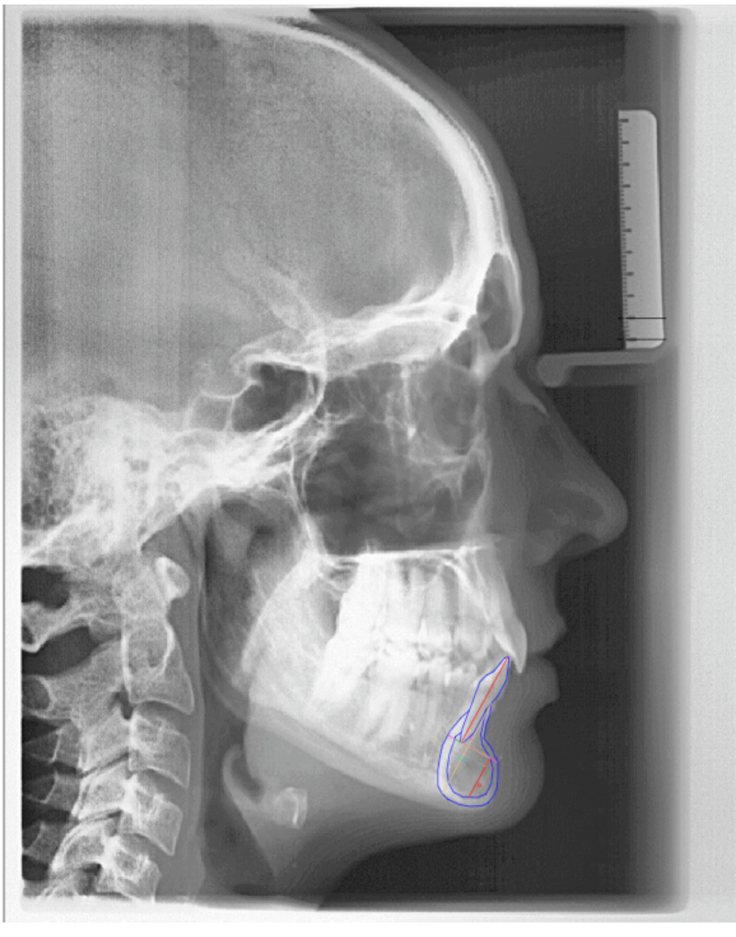

Figure 9: Lateral cephalometric radiography from patient 4

DISCUSSION

In orthodontic diagnosis, the lower incisor relationship with the alveolar bone that supports it, is often a limiting factor when making a treatment plan. The need for extractions in the lower arch is greatly influenced by the amount of supporting bone in the symphysis, the extent of crowding and the incisor position.

This study focuses on the measurement of bone support. The quality and quantity of bone in each patient was measured both on lateral cephalometric radiography and on CBCT. The aim was to compare the results.

Das Kalogiannkis defined the basal bone as the bone which supports and is continuous with the alveolar bone.

In 1948, Salzmann documented that the arrangement of teeth depended on the basal bone. In this regard, a reduced labiolingual size of the alveolar process in the area of the symphysis indicates that the layer of bone supporting the mandibular incisors is thin and susceptible to iatrogenic damage. [4]

Previous studies support that the anatomy of the symphysis depends on sex, location, certain maloclussions and the various facial types.[4]

In males, the symphysis is larger than in females, both buccolingually and in height. Only the vestibular area of the cancellous bone is the same in both.

In our study, we observed differences between the central and lateral incisors. The cancellous bone height and some areas of the symphysis were greater at the central incisors than at the lateral incisors. Therefore, the symphysis is wider at the central incisors, compared with the surrounding areas. Our results are supported by the study of Gracco.[3] However, Uysal did not find any differences between the incisors.[4]

Some authors relate anterior inferior crowding to facial biotype and reduced alveolar bone (Fisk, 1966; Leighton and Hunter, 1982).
On the contrary, other studies conclude that crowding is an independent entity unrelated to facial types (Lundström, 1975; Rainer et al, 1988; Uysal, 2012).

The alveolar bone of the symphysis has also been evaluated in adult patients with mandibular prognathism, in order to establish the limits of orthodontic treatment and the need for orthognathic surgery. In these patients the symphysis is thin, and we must not perform significant movements of the lower incisors. In skeletal class III, lower incisors are usually inclined lingually as the result of dental compensation and the apexes are very close to the vestibular cortical plate.[6,12]

Patients with severe biprotrusion also show thin mandibular symphysis. [2]

They are many studies supporting that the morphology and size of the mandibular symphysis are related to facial biotype. [2-5,12,14]

In dolicofacial patterns, the symphysis is elongated and narrow. Alveolar bone is reduced, so great sagittal movements and rotations pose a high risk of bone and radicular resorption. Long-face pattern is associated with an increase of both lower facial height and mandibular plane. The apex of the lower incisor is closer to the vestibular cortical plate.[2-5,12,14]

Mesofacial patterns show mandibular symphysis with thin buccal and lingual cortical plates.[2]

In brachyfacial patterns, the total width of the mandibular symphysis is greater.

Buccal cortical is thicker. They are also associated with a small gonial angle, small mandibular plane and large posterior facial height. Regarding tooth and bone inclinations, these subjects have more lingually inclined tooth and bone axes. [12]

Gracco asserts that trabecular bone is almost equal in the 3 facial types, although slightly higher in short-faced individuals.[3]

Several investigators have examined the morphology of the alveolar bone in the mandibular incisors using cast models and conventional radiographs.[2,13]

It is almost impossible, however, to examine the labiolingual inclination and thickness of the alveolar bone in the mandibular incisor region using cephalometric radiographs. The bidimensional radiograph representation of this area is plagued by intrinsic errors such as superimposition of anatomic structures, difficulty in identifying single dental elements and magnification error of the x-ray because of the divergence of the radiant beam. This is due to the fact that the radiographic images of the labial and lingual surfaces of the alveolar bone in the mandibular incisor region are projected images of the most anterior and the most posterior parts of the alveolar bone, respectively, and do not correspond specifically to the incisor region.[3,7]

Therefore, a reliable visualization and evaluation of the cortical bony jaw has not been possible until the introduction of computed tomography (CT).
Nawert and Berg, in 1999, indicated that only computed tomography allowed an accurate estimate of labiolingual bone support of the lower incisors.
CT was developed to analyze 3D structures on the three spatial planes and so provide a more realistic image, although the high cost of 3D reconstruction and the high dosage of radiation involved limited its use. [1,3,8]

Cone-beam computed tomography (CBCT), was then developed to reduce the radiation dosage, achieve greater precision on the three spatial planes, and reduce the costs associated with CT. [1,3,8,9,10,11,15.]

This paper compares the results obtained after measuring the lower incisor bone support in the teleradiograph with the results obtained after analyzing the four incisors in CBCT.

In our study, most of the values obtained from lateral cephalometric radiographs were greater than those obtained from CBCT.

It is important to note that in each of the patients, there are differences between the 4 incisors, sometimes insignificant and other times of greater importance. This suggests that the teleradiograph can match the measurement of one of the incisors, but can camouflage a problem in another, because it only shows one incisor, the most protruding.

CONCLUSIONS

The following conclusions can be drawn from our present study:

1. The lateral cephalometric radiograph provides incomplete and insufficient information about the bony support of lower incisors, as it only refers to one of them.

2. In our sample, the alveolar bone is quantitatively and qualitatively different depending on the incisor analyzed.

3. In our patients, the height and width of the symphysis is greater at the lower lateral incisors than at the lower central incisors.

4. The lower incisor represented in the lateral cephalometric radiograph should not be a determining factor when deciding on a treatment plan. The need for dental extractions or orthognathic surgery in some cases, should be analyzed taking account into the four lower incisors.

5. CBCT is a much more reliable diagnostic tool than lateral cephalometric radiograph to measure more accurately and precisely mandibular alveolar bone and incisor position.

REFERENCES

1. Ahmet Yagci, Ilknur Veli, Tancan Uysal, Farukk Izzet Ucar, Törun Ozer, Sukru Enhos. Dehiscence and fenestration in skeletal Class I, II, and III maloclusions assessed with cone-beam computed tomography. Angle Orthod 2012;82:67-74.
2. Chester S. Handelman. The anterior alveolus : its importance in limiting orthodontic treatment and its influence on the occurrence of iatrogenic sequelae. Angle Orthod 1996;66(2):95-110.
3. Antonio Gracco, Lombardo Luca, Maria Cristina Bongiorno, and Giuseppe Siciliani. Computed tomography evaluation of mandibular incisor bony support in untreated patients. Am J Orthod Dentofacial Orthop 2010;138:179-87.
4. Tancan Uysal, Ahmet Yagci, Torun Ozer, Ilknur Veli, and Ahmet Ozturk. Mandibular anterior bony support and incisor crowding: Is there a relationship? Am J Orthod Dentofacial Orthop 2012,142:645-53.
5. Heinrich Wherbein, Waltraud Bauer and Peter Diedrich. Mandibular incisors, alveolar bone, and symphysis afeter orthodontic tratment. A restrospective study. Am J Orthod Dentofac Orthop 1996;110:239-46.
6. Karine Evangelista, Karla de Faria Vasconcelos, Axel Bumann, Edgar Hirsch, Margarita Nitka, and Maria Alves Garcia Silva. Dehiscence and fenestration in patients with Class I and Class II Division 1 maloclussion assessed with cone-beam computed tomography. Am J Orthod Dentofacial Orthop 2010;138:133e1-133e7.
7. Kyung-Min Lee, Yong-Il Kim, Soo-Byung Park, Woo-Sung Son. Alveolar bone loss around lower incisors durin surgical orthodontic treatment in mandibular prognathism. Angle Orthod 2012;82:637-644.
8. Natalia Zamora, Jose M. LLamas, Rosa Cibrián, Jose L. Gandía, Vanessa Paredes. Angle Orthod 2011;81:856-864.
9. Aaron Dean Molen. Considerations in the use of cone-beam computed tomography for buccal bone measurements. Am J Orthod Dentofacial Orthop 2010;137:S130-5.
10. Sebastian Baumgaertel, J.Martin Palomo, Leena Palomo, and Mark G. Hans. Reliability and accuracy of cone-beam computed tomography dental measurements. Am J Orthod Dentofacial Ortop 2009;136:19-28.
11. Adam M. Timock, Valene Cook, Terry McDonald, Michael C. Leo, Jennifer Crowe, Brion L. Benninger and David A. Covell,Jr. Accuracy and reliability of buccal bone height and thickness measurements from cone-beam computed tomography imaging. Am J Orthod Dentofacial Orthop 2011;140:734-44.
12. Masahiro Tsunori, Masamitsu Mashita,Kazutaka Kasai. Relationship between facial types and tooth and bone characteristics of the mandible obtained by

CT scanning. Angle Orthod 1998;68(6):557-562.
13. Chiaki Yamada, Noriyuki Kitai, Naoya Kakimoto, Shumei MUrakami, Souhei Furukawa, and Kenji Takada. Spatial relationships between the mandibular central incisor and associated alveolar bone in adults with mandibular prognathism. Angle Orthod 2007;77(5).
14. Rainer-R.Miethke and Angelika Behm-Menthel. Correlations between lower incisor crowding and lower incisor position and lateral craniofacial morphology. Am J Orthod Dentofac Orthop 1998;94:231-9.
15. Antonio Gracco, Luca Lombardo, Giulia Mancuso; Vincenzo Gravina; Giuseppe Siciliani. Upper incisor position and bony support in untreated patients as seen on CBCT.
16. Vicente Hernandez Soler. Tomografía de haz cónico(1ª parte). Rev Esp Ortod. 2008;38:277-88