

# TOMOGRAPHIC DISTORTION IN TOOTHLESS PATIENTS

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## ABSTRACT

The main aim of this work is to compare the measurements of paraxial slices of the standard Denta-Scan technique and a new technique (Occlusal technique) in toothless patients. On a more specific level, our goal is to assess the effect of a change in the reference plane of computer axial tomography (CAT), for which the Denta-Scan system is usually employed, by transferring the palate plane to the prosthetic plane, which goes from the center of the external auditory canal to the anterior nasal spine.

For the experiment, 15 maxillaries were used from toothless skulls belonging to adult patients who had lost their teeth prior to their death. For each one, a wax rim was made in reference to the Occlusal Plane (Camper's Prosthetic Plane) and a 10 mm x 3.3 mm reference implant was placed. Two tomography scans were made of each skull; one using the conventional technique, and the other using Camper's Prosthetic Plane. The tomograph used was of the helicoid type (Phillips MX8000),

with 1.3 mm slices every 0.6 mm. To perform the comparative measurements between the two techniques, a VIS Caliper (Poland), was employed, and the data recorded in a table with the reference of each sample and technique. This was repeated with all 15 skulls.

The results obtained were evaluated with the measurement of the reference implant for each technique. It was found that the standard technique (Horizontal Plane) showed 19.20% magnification, as opposed to the technique under examination (Camper's Occlusal Plane), which showed 16.5% magnification.

The study showed distortions in each measurement as regards the real measurements of the reference implants. These distortions were less significant in the case of the Occlusal Plane technique than in the Horizontal Technique; however, neither of them fully matched the measurements of the reference implant.

**Key words:** Tomography, prosthesis, occlusal plane.

## DISTORCIÓN DE LA TOMOGRAFÍA EN LOS PACIENTES DESDENTADOS

### RESUMEN

Uno de los métodos de diagnóstico por imágenes en implantología es la tomografía axial computada. El plano de referencia utilizado para realizar el estudio es el Plano Horizontal, que se toma paralelo al techo de la bóveda palatina. La referencia utilizada en el acto quirúrgico es el Plano Oclusal (Plano protético de Cámpere) a partir del cual se confecciona la guía quirúrgica; por lo cual si cambiáramos la referencia utilizada en la tomografía al Plano de Oclusión, podríamos tener una imagen más real del hueso.

Para realizar la experiencia, se seleccionaron 15 cráneos desdentados maxilar superior de personas adultas que habían perdido sus piezas dentarias con anterioridad a su deceso. A cada uno de ellos se les confeccionó un rodete de cera con referencia al Plano Oclusal (Protético de Camper) y se les colocó un implante testigo de 10 mm x 3,3 mm. Se tomaron dos tomografías de cada cráneo, una con la técnica convencional y otra utilizando el Plano Protético de Camper. El tomógrafo utiliza-

do fue del tipo helicoidal, marca Philips MX8000, con cortes de 1,3 mm cada 0,6mm. Para poder realizar la medición comparativa entre una y otra técnica se utilizó un Calibre milimetrado marca VIS (Poland) y se registraron las mediciones en una tabla con la referencia de cada muestra y técnica perteneciente. La experiencia se repitió con los 15 cráneos.

Se evaluaron los resultados obtenidos con la medida de cada implante testigo con cada técnica. Se pudo observar que la técnica estándar (Horizontal) mostró una magnificación del 19,20% con respecto a la técnica en estudio (Oclusal) que mostró una magnificación del 16,5%.

El estudio mostró distorsiones en cada medida con respecto a las reales de los implantes testigos. Estas distorsiones fueron menores en el caso de la Técnica Oclusal en relación a la Técnica Horizontal; sin embargo, ninguna de ellas coincidió con la medida del testigo.

**Palabras clave:** Tomografía, prótesis, plano oclusal.

### INTRODUCTION

One of the challenges faced at the time of planning implant surgery is the correct diagnosis of the area to be operated on, which is an essential stage in order to achieve the expected results<sup>1</sup>. Among the diagnostic methods available, image diagnosis is undoubtedly one of the most commonly used, as it

is a necessary tool<sup>2</sup> to obtain a clear idea of what may be encountered during surgery<sup>3</sup>.

Of all existing options, computer axial tomography is currently considered to be the most accurate<sup>4</sup>, having little or no distortion, which means that it reproduces perfectly the anatomy of the bone under examination. The tomograph uses computer soft-

ware called Denta-Scan, by means of which a supposedly real accuracy in measurements is achieved. Denta-Scan tomography scans slices throughout the maxillary and shows each portion as a millimetered image, which means that although there should be no difference regarding real size, these slices would be subject to the reference plane for which the tomograph has been programmed to perform the first slice<sup>5</sup>.

In the case of tomography, the reference plane used is a horizontal plane taken parallel to the palate. This provides paraxial sections of the bone of certain measurements from which diagnosis is made and the surgical procedure decided upon<sup>6</sup>.

From the point of view of implant placement, both for the diagnosis and model planning and for the surgical procedure, the reference used is the occlusal plane. This plane runs parallel to another plane used in prosthesis known as Camper's plane<sup>7</sup>, and which is the reference used in order to determine the correct position of the implant. This plane is another imaginary line that goes from the center of the external auditory canal to the anterior nasal spine. Therefore, if the reference for the clinical and surgical study is the occlusal plane, there would be a discrepancy as regards the reference plane used for diagnosis from the images derived from the computer axial tomography scans provided by Denta-Scan. This means that if we changed the reference used in computer tomography and used the occlusal plane instead, we could have a more real image of the bone in the paraxial slice.

The general aim of this study was to compare the measurements of the paraxial slices with both techniques in toothless patients. As regards the specific aim, we focused on the effect of changing the reference plane of Denta-Scan computer axial tomography, transferring the palate plane to the plane of prosthetic utilization, which goes from the center of the external auditory canal to the anterior nasal spine.

## MATERIALS AND METHODS

In order to carry out the study, 15 toothless maxillaries were selected, belonging to adult patients who had lost their teeth prior to their death<sup>8</sup>. These skulls were chosen at random.

The first step consisted of making pink wax rims for the maxilla, with an occlusal plane that was parallel to Camper's Plane, according to standard

criteria used in the preparation of a complete prosthesis. To do this, an alginate impression was made (C.A. 37 Caulk) of the full toothless maxillary bone and a plaster cast (Bayer) was made to obtain the model<sup>9</sup>.

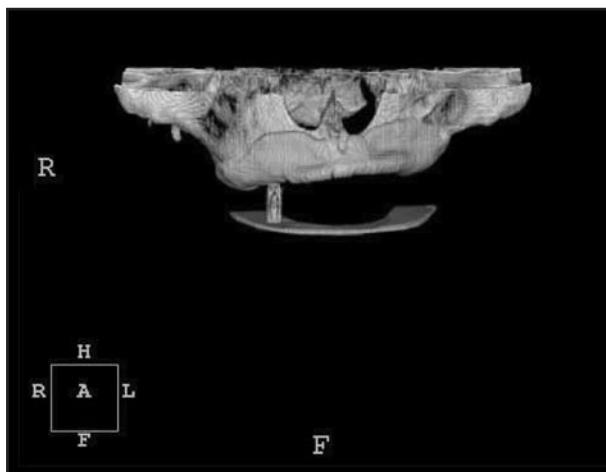
Once the replica was finished and cut, the wax rim was made to simulate the patient's occlusal plane. First, the model was painted with solid Vaseline and after this a Base-Plate was heated with a Bunsen burner in order to adapt it to the model's anatomy, removing excess material.

Once the base plate was ready, a pink wax sheet was rolled using the heat from the burner. The wax sheet was bent and placed over the base plate in the shape of a horseshoe, following the arch and replacing the missing teeth<sup>10</sup>. Then the wax was given the shape of a square with well-defined angles and a height of 22 mm throughout the arch. A flat surface was thus obtained that could represent the occlusal surfaces of all the missing teeth.

To prevent the rim from rolling or swinging, a heat stabilization procedure was performed directly onto the maxillary; the wax rim was previously painted with solid Vaseline so that it would not adhere to the bone. In order to position the skull's occlusal plane, the principle of prosthetic parallelism (formed by the occlusal plane and Camper's Plane) described in the *Introduction* was used. The instrument employed was a standard acrylic Fox Plane and a VIS millimetered caliper (Poland).

The rim was placed on its occlusal surface and Fox Plane was positioned. Next, Camper's Plane was determined by means of a ruler, taking into account frontal and lateral views. For the frontal view, the references used were the infraorbital foramen and infraorbital ridge; for the lateral views, the references used were the anterior nasal spine and the external auditory canal. Parallelism between the abovementioned planes was established by means of the reference points and Fox Plane, removing or adding wax as necessary.

Once the occlusal plane was obtained, the following step was to place the implants throughout the rim's occlusal surface, which would enable us to perform the measurements used as references in the tomographic study. To do so, the location of the reference implant that would produce the best image was determined, since the variation in the measurement between the plane that is normally used in tomographic scans (palate plane) and the reference



*Fig. 1: Coronal 3D view of implant location, in reference to Occlusal Plane.*



*Fig. 2: Axial 3D view of implant location, in reference to Occlusal Plane.*

plane under examination (occlusal plane) would depend on it.

In order to carry out our analysis, the surface of the rim was divided into four quadrants, and an implant was placed in each of them. Of all the quadrants analyzed, the selected area was the one that corresponded to the Left Premolar region, since implants can be placed in better axiality in comparison with the asymmetric resorption of the other areas. Each implant was placed perpendicularly to the occlusal plane simulating the insertion axis used in a standard surgical procedure, which would be given by a surgical guide in a toothless patient or tooth alignment in the case of a partially toothless patient. In order for the Occlusal Plane to appear as one line in a tomographic lateral view, a radiopaque sheet was placed on the surface of the wax rim.

The implant used as a reference was a Branemark (Nobel Biocare) titanium implant which was 10 mm in length and had a diameter of 3.3 mm. It was selected for the study because it produced low artifact level regarding image quality, and because of its design features (Fig. 1 and 2).

Two tomographic scans were taken of each skull with the same wax rim and reference implant. One of the tomographic scans used the standard technique (i.e. the Horizontal Plane), while the other used the Occlusal Plane technique. In order to perform both techniques, the skulls were first fixed to the head of the gurney to prevent any movement. The location of the skulls was determined by a laser beam which rendered the correct positioning for the analysis.

The equipment used was a new helicoid tomograph. With this kind of tomograph, the sample moves along with the gurney while the ray tube shoots continuously, providing uninterrupted spiral slices. The information gathered with this technique can be digitally processed later on, obtaining a 1.3 mm thickness every 0.6 mm.

The first image we obtained was the lateral view of the skull known as Scout View. After this, the area of analysis was established, taking as reference the lateral image of the skull from above the palate to below the wax rim (Fig. 3 and 4). Following this, the equipment reformatted the images parallel to the Horizontal and Occlusal Plane, creating an arch or horseshoe model. The tomographist selected the location points along the arch and in its center, connecting them to form a line that ran along the arch of the bone under examination. This line establishes the place from which the tomograph is to gather the information for creating the perpendicular paraxial images as well as the panorex slices. Panorex slices are a full panoramic view from left to right of the complete unit under examination<sup>11</sup>. Depending on the thickness between the external and the inner table, these slices can be two, three, four or even five, showing the different depths. Each panorex slice is 2 mm thick every 2 mm. At the bottom of the panoramic image there is a numbered table from which the height of the area under examination could be selected. The paraxial slice of the reference implant was checked against this reference. In order to perform a comparative measurement of both techniques, we used the scale on

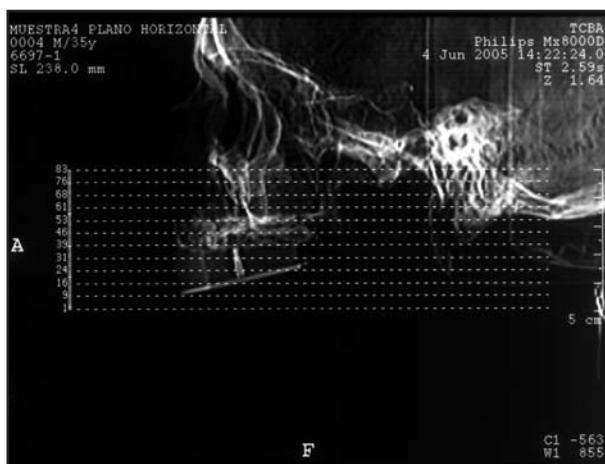


Fig. 3: Lateral Scout View for conventional Horizontal Plane technique. (the slices are parallel to the palate).

the left margin of each slice, a compass and a caliper. This scale is a real 3 cm scale but can also be a mm range scale depending on the information provided by the tomograph.

Since the software employed reconstructs each paraxial slice every 2 mm, and since the reference implant has a diameter of 3 mm, part of the information gathered appeared in one or two slices depending on the reconstruction slice<sup>12</sup>.

As long as the implantologist performs the correct prosthetic planning<sup>13</sup>, the axial placement of an implant that is perpendicular to the occlusal plane should not be a difficult task, and this axiality should guarantee the successful placement of the implant when this is subjected to masticatory load in the future<sup>14</sup>. However, placing an implant in tomographic axiality, i.e. in such a way that its entire length can be seen in a paraxial slice, is a matter of chance, taking into account that, as mentioned above, Denta-Scan reconstruction takes place every 2 mm.

Therefore, when the length of the implant was observed in one paraxial slice, the implant measurement was transferred to the caliper's scale with a compass and registered in a table together with the sample and technique references. When the reconstruction slice took place in the middle of the implant, the image was repeated in two slices, with part of the information in one slice, and part of the information in the other slice, which meant that the top of the implant was registered in one slice and its base in another slice. In order to transfer the measurements accurately, a ruler and a set square were used as follows:

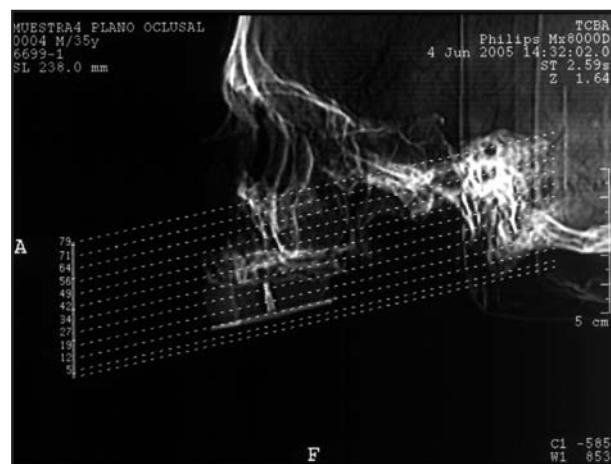


Fig. 4: Lateral Scout View for Occlusal Plane technique (the slices are parallel to the Occlusal plane).

A ruler was placed on the mm scale provided by the software on the film.

A set square was moved perpendicularly to the ruler until it reached the top of the implant, and a line was drawn from this point to the scale.

This was repeated with the other slice, marking the base of the implant.

Since the paraxial slice scale is at the same height in all slices as regards the image, measurements could be unified in one slice by means of counting the lines in one slice and transferring them to the other slice. After this, the distance established was measured with the compass, transferred to the caliper and recorded in Table 1 (Figs. 5 and 6). This methodology was repeated for both techniques with all fifteen samples. To assess the results, a comparative table was made with the measurements of the reference implants obtained with each technique.

## RESULTS

In order to assess the results<sup>15</sup>, a table was constructed where we could observe each of the samples with the variations derived from each technique and the position of the tomographic slice where the measurement was taken (Table 1).

The statistics obtained were of the descriptive type, where both techniques or 'variables' were interrelated, grouped in pairs with the reference implant with a standard deviation of 0.0746 for the horizontal technique and 0.1506 for the occlusal technique. The statistic method employed was the Student Test. When each sample was tested with the reference value, we found that the p value was lower

**TABLE 1. Results of measurements expressed in millimeters**

| SAMPLE | ABSOLUTE MEASUREMENT. | HORIZONTAL TECHNIQUE | TOMOG. SLICE. | OCCLUSAL TECHNIQUE | TOMOG. SLICE |
|--------|-----------------------|----------------------|---------------|--------------------|--------------|
| 1      | 10.00                 | 12.00                | 16-17         | 11.80              | 16-17        |
| 2      | 10.00                 | 11.90                | 16            | 11.70              | 16-17        |
| 3      | 10.00                 | 11.90                | 22            | 11.80              | 22           |
| 4      | 10.00                 | 11.80                | 19            | 11.60              | 23           |
| 5      | 10.00                 | 12.00                | 22            | 11.50              | 21-22        |
| 6      | 10.00                 | 12.00                | 19            | 11.80              | 20           |
| 7      | 10.00                 | 11.80                | 19            | 11.90              | 22           |
| 8      | 10.00                 | 12.00                | 19-20         | 11.80              | 22           |
| 9      | 10.00                 | 11.90                | 13-14         | 11.80              | 18           |
| 10     | 10.00                 | 11.80                | 15-16         | 11.60              | 19-20        |
| 11     | 10.00                 | 12.00                | 14            | 11.50              | 18-19        |
| 12     | 10.00                 | 11.90                | 22            | 11.50              | 23           |
| 13     | 10.00                 | 11.90                | 16-17         | 11.50              | 20-21        |
| 14     | 10.00                 | 11.90                | 19-20         | 11.50              | 22           |
| 15     | 10.00                 | 12.00                | 18-19         | 11.50              | 21           |

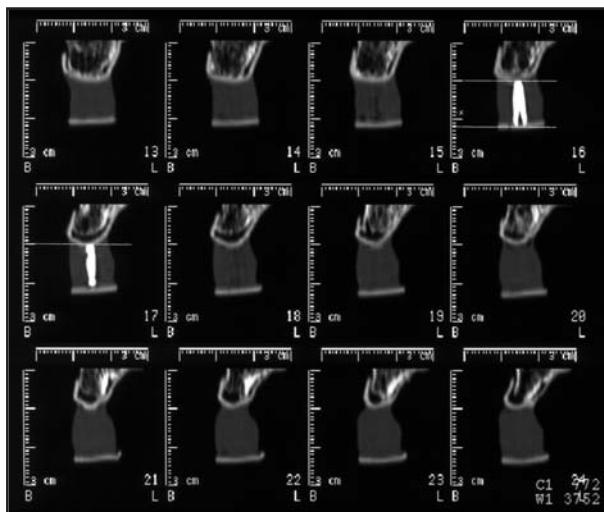


Fig. 5: Oblique reformatted views of reference implant for Horizontal Technique.

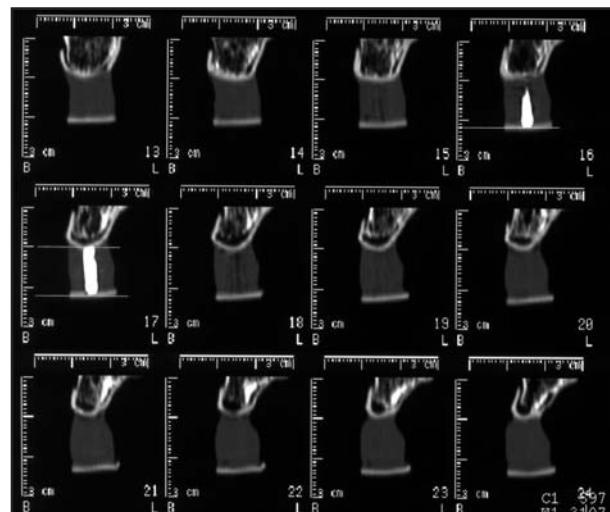


Fig. 6: Occlusal Technique.

than 0.05, which was the value taken as reference. This shows that significantly different values were obtained with both techniques regarding the measurements of the reference implants.

Comparing the two techniques, the value of  $p$  was also lower than 0.05 and we could see that there were differences between them, proving that the two techniques are not the same. The histogram showed that the tendency was for the occlusal technique to be closer to the measurements of the reference implants than the horizontal technique (Fig. 7).

As regards percentages, the standard technique showed 19.20% magnification compared to the occlusal technique, which showed 16.5% magnification.

## DISCUSSION

When the technician depends only on anatomic features, they may be enough for the study of an organ, but this is not the case when it comes to taking measurements and then planning work based upon them. Therefore, a Denta-Scan study with a prosthetic tomographic guide for toothless patients would show a more real bone/implant relation

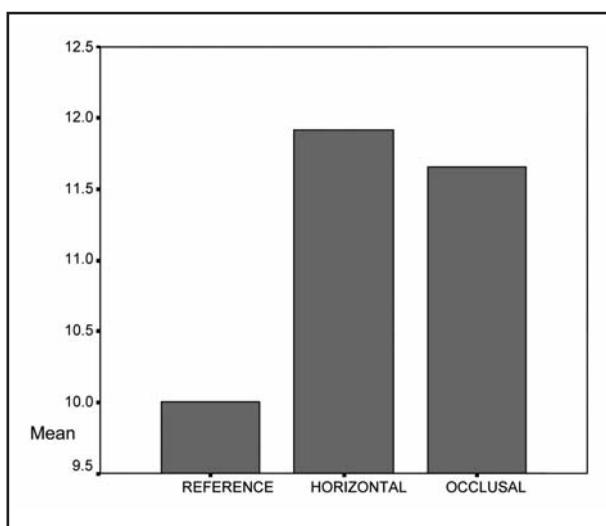


Fig. 7: Histogram with measurement distribution averages.

which would allow us to make a more reliable surgical guide taking into account distortions. These distortions were lower for the technique that used the prosthetic plane rather than the anatomic plane. Moreover, these differences should be considered of significant importance when it comes to planning surgery around critical anatomical areas, such as the maxillary sinus, nostrils, inferior dental nerve, etc. The studies performed by authors such as Cavalcanti et al.<sup>16</sup> did not take into account the changes in the reference planes as regards the angles of the Gantrix tomographer or in the case of studies such as Kohavi et al.<sup>17</sup> where the angles were taken with the measurements of preset angles for all samples. The reference in our study was given to the technician with reference to the specific occlusal plane for each skull, once the correct prosthetic plane had been determined. Considering the fact that available literature states that a radiograph has a distortion ranging from 25% to 30%, which would make it unreliable in this sense, according to this study, the distortion percentage can be reduced dramatically when the occlusal technique is employed. However, we still do not have a diagnostic technique that is 100% reliable. Although the number of samples was not large, the results obtained show that the variations were constant,

which would surely lead to similar results had we examined a larger group of samples. It is clear then, that if we used the prosthetic-tomographic guide we would minimize distortion regarding bone measurement for the placement of an implant and we could have a more reliable surgical guide true to the existing bone.

## CONCLUSION

An analysis of the statistic results allows us to say that the use of the tomographic technique by Denta-Scan system with a reference plane that could guide the tomographist in the study would provide measurements that are somewhat closer to reality<sup>18</sup>. Nevertheless, the study showed distortions regarding the real measurements of reference implants with both techniques. Despite the fact that no technique was 100% true to reality, these distortions were smaller in the case of the Occlusal Technique than the Horizontal Technique. This was very important when we analyzed the results of this study, since if we normally speak of a 1 to 1 ratio, and tomography did not show this. Taking into account the fact that the number of samples was not large, the tendency repeated in each of them suggested that the results would still be constant if we used a larger number of samples. Similarly, from the Student Test analysis, for each technique, the p value was lower than 0.05, showing the variation between techniques and the absolute length of the reference implant. When the Student Test was applied between the Horizontal and Occlusal techniques, the p value was also lower than 0.05, which proved that the two techniques differ. The analysis of the results obtained showed that the occlusal technique was closer to the measurements of the reference implant than the horizontal technique. Regarding percentages, the standard technique (Horizontal) showed 19.20% magnification in comparison to the technique under examination (Occlusal), which showed 16.5% magnification. To sum up, if a tomographic and surgical guide is prepared taking the occlusal-prosthetic plane as reference, a better representation of reality will be obtained, which will in turn minimize the incorrect interpretation regarding the depth of existing bone.

## CORRESPONDENCE

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