Artigo

ACCURACY OF CAD/CAM SURGICAL GUIDES OF TITANIUM AND THERMOPLASTIC TO GENIOPLASTY

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ABSTRACT: Purpose: to analyze the accuracy of two different CAD / CAM guides for genioplasty through 3D image overlays: biocompatible thermoplastic CAD / CAM guide dental support and fixation through preformed plate and group two: titanium CAD / CAM guide bone support and fixation with customized plate. Materials and methods: prospective study involving two groups of eight patient. The overlap of 3D images of the virtual and postoperative planning determining the difference in millimeters of the movements. The calculations were performed using the 3D interactive
proximity algorithm and the linear method. Results: using a 3D method, the thermoplastic guide showed a mean of 0.24 mm and standard deviation (SD) 1.06 mm while the mean titanium value was 0.25 mm and DP 0.79 mm. using the linear method, the thermoplastic presented a mean of 0.98 mm and a DP of 0.83. 91.7% of the movements were smaller than 2 mm and 65.2% below 1 mm. In titanium, mean of 0.81 mm and SD of 0.72. 91.7% of the movements were smaller than 2 mm and 69.4% were smaller than 1 mm. Conclusion: Thermoplastic and titanium CAD / CAM guides are reliable and acuracy methods for genioplasty

KEYWORDS: Orthognathic Surgery, Osteotomy, Le Fort, Splints, Surgical Fixation Devices, Computer-Aided Design.

RESUMO: Objetivo: analisar a acurácia de dois diferentes guias CAD/CAM para genioplastia através de sobreposições de imagens 3D: guia CAD/CAM termoplástico biocompatível, com suporte dentário e fixação através de placa pré-conformada e o segundo grupo com guia CAD/CAM em titânio com suporte ósseo e fixação com placa customizada de titânio. Materiais e métodos: estudo prospetivo envolvendo dois grupos de oito pacientes submetidos a genioplastia, através da sobreposição de imagens 3D do planejamento virtual e pós-operatório, determinando a diferença em milímetros dos movimentos. Os cálculos foram realizados utilizando o algoritmo de proximidade interativo 3D e o método linear. Resultados: pelo método 3D, o guia de termoplástico apresentou uma média de 0,24 mm e desvio padrão (DP) de 1,06 mm, enquanto o valor médio do titânio foi de 0,25 mm e DP de 0,79 mm. Pelo método linear, o termoplástico apresentou uma média de 0,98 mm e DP de 0,83. 91,7% dos movimentos foram menores que 2 mm e 65,2% menores que 1 mm. No titânio, média de 0,81 mm e DP de 0,72. 91,7% dos movimentos foram inferiores a 2 mm e 69,4% foram inferiores a 1 mm. Conclusão: Os guias CAD/CAM de termoplástico e titânio são métodos confiáveis e precisos para a genioplastia

PALAVRAS-CHAVE: Cirurgia Ortognática, Osteotomia Le Fort, Splints, Dispositivos de Fixação Cirúrgica, Desenho Assistido por Computador.
1. Introduction

The chin have an important role in the harmony of the face, because its positioning influences the profile, the height of the lower third and the facial symmetry, besides improving the posture of the lower lip. The milohyoid muscles, the anterior belly of the digastric, genioglossus and geniohyoid muscles, which are important for mastication and exert influence on the best positioning of the tongue and the maintenance of the pharyngeal space.

Many patients who undergo orthognathic surgery require genioplasty, either to correct bone asymmetries, the need for advancement or retreat for aesthetic or functional purpose. In some cases, repositioning is critical to face harmony. In functional cases, such as obstructive sleep apnea, when the chin is advanced, the muscles are repositioned anteriorly, which increases the pharyngeal space and improves the symptoms of apnea.

In the conventional surgical method of genioplasty, the surgeon does the free hand osteotomy, based on the patient's anatomy, using intra- and extra-oral references; then the chin is fixed in position with a preformed miniature titanium plate and secured with 4 titanium screws. Thus, the predictability of surgery is dependent on the experience, technique and dexterity of the surgeon.

CAD / CAM (Computer-aided design / Computer-aided manufactured) technology has come to optimize and improve the results obtained by the conventional method, through the use of software that simulates dento-skeletal surgical movements, concomitantly with the soft tissue of the face. The CAD / CAM surgical guides and custom titanium mini-plates have the function of transferring the information and movements predefined in the virtual planning to the operative field. In this way, complex surgeries
are transformed into simple procedures, providing greater precision, safety and predictability.\textsuperscript{2,15}

The present work aims to compare and evaluate the accuracy of two different CAD / CAM surgical guides, created in a virtual environment, manufactured using 3D printing and used to guide the cutting, perforations and final position of the chin: 1) Thermoplastic guide, with dental support and fixation with preformed plate and 2) Guide of titanium, with bony support and fixation of chin with customized miniplate.

Materials and methods: The study was approved by the Ethics Committee on Research in Human Beings of the Tropical Medicine Nucleus of the Health Sciences Institute of the Federal University of Pará - ICS / UFPA: 64219616.0.0000.5172. Opinion No. 2,372,124. All the patients received individualized explanations about the research, and freely accepted to participate by signing the informed consent form.

This prospective study was carried out by the team of Oral and Maxillofacial Surgery of the Ophir Loyola Hospital and the master's program in dentistry of the Federal University of Pará, Belém do Pará, Brazil, from January 2016 to June 2017.

Sample was composed of 16 people who did virtual planning using CAD / CAM guide for genioplasty. The selection was random, forming two groups of eight people, according to the criteria below:

Inclusion criteria: a) To be operated by the same team; b) To be submitted to orthognathic surgery with virtual planning using CAD / CAM guide for genioplasty; c) Helical computed tomography ("multislice") of the face (Toshiba Aquilion 64 X tomograph, Tokyo, Japan) in the preoperative and postoperative period (up to 7 days postoperatively). Exclusion criteria: a) Patients younger than 18 years; b) Patients undergoing any type of previous surgery in the hospital. Patients with no asymmetry in chin.
The first group consisted of 8 people, 6 women and 2 men, with a mean age of 31.5 (22-35 years). In these patients was used the CAD / CAM thermoplastic guide supported on the occlusal mandibular teeth and fixed with preformed plates.

For the making of this guide, we used the initial and final planning files in the STL (Stereolithography) format. The guides for genioplasty were modeled in the 3D CAD program (Autodesk.com, San Rafael, USA) and fabricated on a 50 micron resolution 3D printer using biocompatible thermoplastic material. This biomaterial consists of a monofilament polymer of circular section and diameter of 1.75 mm, by Aditiv Laboratory (Aditiv.com, Rio de Janeiro, Brazil). This guide is composed of 4 pieces: 1º) Guide of cut and initial positioning; 20) Initial positioning palette; 30) Occlusal support splint; 40) Pallet to guide the final positioning. After the chin is placed in the planned three-dimensional final position, it is then fixed with a conventional preformed plate 16 (Figure 1A and 1B).

Figure. 1 Guide made of thermoplastic material, for genioplasty. A: Template for initial positioning of the chin. B: Chin positioned and fixed with preformed plate, system 2.0.

For group 2, 8 patients were selected, 4 women and 4 men, with mean age of 30 (20 and 40 years). In this group we used the titanium CAD / CAM guide (Guia 2), designed in the 3-Matic program (Materialise.com, Leuven, Belgium) and manufactured in 3D laser printer SLM®500 (SLM-solution.com,
Lübeck, Germany) with a resolution of 50 micron. Guide 2 consists of two pieces: 1) Titanium initial guide for cutting and drilling, with bony support in the anterior region of the jaw 2) custom made titanium miniplate, of system 2.0, which positions the three-dimensional osteotomized chin as defined in the virtual planning, guided by the pre-defined perforations. (Figure 2A and 2B).

![Figure 2A: Cutting and drilling template. 2B: Custom fixing plate, 2.0 system. Final positioning of the chin which was oriented by the plate.](image)

Source: doctor José Thiers

In order to evaluate the accuracy of the surgeries with the guides, the three-dimensional images of the virtual planning (T0) were superimposed with those of the postoperative period of up to 7 days after the genioplasty (T1). followed by calculations of the differences between the planned movements and those obtained surgically.
For alignment of the chin, anatomical points were defined in the mandible, which do not change in the postoperative period. In the present study, the mesiobuccal cusp of the first mandibular molars, the incisal of the mandibular central incisors and the right and left mandibular foramen were chosen.

To calculate the accuracy of the guides, for both groups, Cloudcompare software (Cloudcompare.org, Paris, France) was used. By which the three-dimensional discrepancies of the measurements in millimeters are determined, through two methods of analysis.

The first method uses the surface matching method by the nearest interactive point (ICP) algorithm 17-18. In this way, the mean value and standard deviation of all points on the surface of the three-dimensional mesh of the selected image of the superimposed chin were found. In addition, this method provides the visualization of chin movements in the overlapped image through a color scale and the percentage of movements smaller than 2 mm. Figure 4
The second methodology used to verify the accuracy of the guides provides the calculation of the linear differences in millimeters between each of the 3 pairs of reference points marked in the chin, comparing the 3D image of the virtual planning with the postoperative tomography. These points are measured in the 3 planes: X, Y and Z. The marking of these three reference points is performed on the virtual surgery planning image (T0) and maintained on the 3D image obtained from the postoperative tomography (T1).16 in the image of the virtual planning of the mentoplasty is made the marking of the point R0 (Menton). The marking of point R1 is on the left side and perpendicular to the mental foramen in the center of the mandible base, and marking of the R2 point on the right side and parallel to the mental foramen in the center of the jaw base. (Figure. 5)
The linear distances in mm of the measurements between points R0 and points R1 and R2 were recorded in the reference model and applied in the same way on the postoperative tomography image at points A0 (Me), A1 and A2. In this way, the linear differences of the point movements in the overlapping images were visualized using the Cloudcompare software alignment tool, which provides the individual three-dimensional position in the pre- and postoperative period separately from each point in the 3 axes (X, Y, Z). By subtracting the initial spatial data with the end of each corresponding point, the data regarding the degree of precision of the performed surgery was obtained. (Figure 6). This data was tabulated in the Microsoft Excel 2016 program.

Figure. 6. Image overlap with reference points illustrating the planned and obtained position in the genioplasty using a CAD / CAM guide.
2. Results

In order to evaluate the reliability of the examiner in the overlapping and quantification of the movements between the planning and the postoperative, the interclass correlation index (ICC) with 95% confidence interval was used, of which 20% of the sample were randomly selected and overlapping. The examiner was blinded and repeated all steps of the above-mentioned image processing protocol four weeks after the initial evaluation. The result of the ICC was 0.96 on the X axis, 0.95 on the Y axis and 0.96 on the Z axis. The nearest results of 1 are best. The results of the examiner's reliability were considered satisfactory. The results obtained in the present work are shown in the tables below.

Table 1. Patients submitted to genioplasty with thermoplastic CAD / CAM guide with occlusal support and preformed plates. Mean and standard deviation in millimeters of the overlap of the virtual planning images with the postoperative tomography using the CloudCompare software. Patients mean age Standard deviation.

<table>
<thead>
<tr>
<th>Patients</th>
<th>Age</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
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<tbody>
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<td>1</td>
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<td>0.41</td>
<td>1.39</td>
</tr>
<tr>
<td>2</td>
<td>35</td>
<td>0.45</td>
<td>0.92</td>
</tr>
<tr>
<td>3</td>
<td>32</td>
<td>0.25</td>
<td>1.09</td>
</tr>
<tr>
<td>4</td>
<td>35</td>
<td>0.39</td>
<td>1.73</td>
</tr>
<tr>
<td>5</td>
<td>42</td>
<td>0.11</td>
<td>0.85</td>
</tr>
<tr>
<td>6</td>
<td>32</td>
<td>0.06</td>
<td>1.09</td>
</tr>
<tr>
<td>7</td>
<td>23</td>
<td>0.17</td>
<td>1.08</td>
</tr>
<tr>
<td>8</td>
<td>25</td>
<td>0.26</td>
<td>0.66</td>
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</tbody>
</table>

Source: Doctor Douglas Voss
### Table 2. Patients undergoing genioplasty with titanium CAD / CAM guide using bone support and custom made miniplate. Mean and standard deviation in millimeters of overlap of virtual planning images with postoperative tomography using CloudCompare software.

<table>
<thead>
<tr>
<th>Patients</th>
<th>Age</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
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<td>1</td>
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<td>0.37</td>
<td>1.10</td>
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<tr>
<td>3</td>
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<tr>
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<tr>
<td>8</td>
<td>28</td>
<td>0.25</td>
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</table>

Source: Doctor Douglas Voss

### Table 3. Patients undergoing mentoplasty with CAD / CAM thermoplastic guidewire with occlusal support and preformed plates. Mean in millimeters of linear motion at points O, 1 and 2 on X, Y and Z axes using CloudCompare software.

<table>
<thead>
<tr>
<th>Pat.</th>
<th>0x</th>
<th>1x</th>
<th>2x</th>
<th>0y</th>
<th>1y</th>
<th>2y</th>
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<td>1.6</td>
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</tr>
<tr>
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</tr>
<tr>
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</tr>
<tr>
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<td>1.1</td>
<td>0.5</td>
<td>0.3</td>
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<td>0</td>
<td>2.3</td>
<td>1.8</td>
<td>1.9</td>
</tr>
<tr>
<td>6</td>
<td>0.5</td>
<td>0.4</td>
<td>0.7</td>
<td>0.8</td>
<td>3.6</td>
<td>1.9</td>
<td>2.4</td>
<td>1.6</td>
<td>1.3</td>
</tr>
<tr>
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<td>1</td>
<td>0.6</td>
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<td>1.7</td>
<td>1</td>
<td>1</td>
<td>0.9</td>
</tr>
<tr>
<td>8</td>
<td>0.7</td>
<td>0.4</td>
<td>0.1</td>
<td>1.1</td>
<td>0.4</td>
<td>0.7</td>
<td>0.2</td>
<td>0.6</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Abbreviations: Pat. = patients; x = x-axis; y = y-axis; z = z-axis.

Source: Doctor Douglas Voss

### Table 4. Patients undergoing genioplasty with titanium CAD / CAM guide with bone support and mini-plate customized plate. Average in millimeters of the 3-point overlap on the X, Y, and Z axis using the Cloud Compare software. Source Doctor Douglas Voss

<table>
<thead>
<tr>
<th>Pac</th>
<th>0x</th>
<th>1x</th>
<th>2x</th>
<th>0y</th>
<th>1y</th>
<th>2y</th>
<th>0z</th>
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<tbody>
<tr>
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<td>0.9</td>
<td>0.4</td>
<td>0.5</td>
<td>0.2</td>
<td>0.3</td>
</tr>
<tr>
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<td>1.3</td>
<td>0.2</td>
<td>0.2</td>
<td>0.4</td>
<td>1.8</td>
<td>0.2</td>
<td>2.3</td>
<td>1.1</td>
</tr>
<tr>
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<td>0.4</td>
<td>1.3</td>
<td>3.4</td>
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<td>0.7</td>
<td>1.4</td>
<td>2.2</td>
</tr>
<tr>
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<td>0.3</td>
<td>0.5</td>
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<td>0.7</td>
<td>0.1</td>
<td>0.8</td>
<td>1</td>
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</tbody>
</table>
To calculate the linear movement, the difference between the virtual planning and the postoperative tomography was calculated. Positive results were used, since for the Bland-Altman method and 3D computerized analysis by points comparison, positive and negative results were used, because the movements in three dimensions are registered with positive or negative sign depending on their three-dimensional location in the Cartesian plane. For example, movements for posterior on the Y axis, lower on the Y axis, or for the right on the X axis are recorded as negative, movements to the anterior on the Y axis, upper on the Z axis, or left on the X axis are recorded as positive. Figure. 7.

Figure. 7 Three-dimensional Cartesian coordinates.


Abbreviations: Pat. = patients; x = x-axis; y = y-axis; z = z-axis.
Source: Doctor Douglas Voss
Due to the frontal positioning of the chin on the software screen (Figure. 8) the anteroposterior direction ends up being the Z axis, the lateral the X and the upper and lower Z axis. Source Doctor Douglas Voss

The results showed that the thermoplastic group showed a moving average of 0.24 mm and standard deviation (SD) 1.06 mm, while the titanium group showed a mean of 0.25 mm and a standard deviation of 0.79 mm. Using the linear method of analysis, the thermoplastic group had a mean of 0.98 mm and standard deviation of 0.83, and the titanium group, mean of 0.81 mm and standard deviation of 0.72.

Using the linear analysis method, we can divide the two groups in the 3 axes (X, Y and Z), and when analyzing the results, the two guides behaved similarly in the 3 axes, presenting better results in the X axis (lateral) and worse results on the Y axis. The Z axis represented the vertical. The mean deviation in the thermoplastic guide by this evaluative method in the X axis
was 0.72 with SD of 0.43 mm; the mean in the Y axis was 1.14 mm with SD of 1.13 mm and in the Z axis the mean deviation was 1.07 with SD of 0.73 mm. The lowest movement reached 0.1 mm and the highest 3.7 mm. 91.7% of the movements were smaller than 2 mm and 65.2% below 1 mm. In the titanium guide the mean deviation in the X-axis was 0.69 mm with a DP of 0.48 mm, mean in the Y axis was 0.96 mm with a DP of 0.89 mm and in the Z axis the mean was 0.79 mm with a DP of 0.72 mm. The lowest movement reached 0 mm and the largest 3.4 mm. 91.7% of the movements were smaller than 2 mm and 69.4% of the movements were smaller than 1 mm.

The CAD / CAM guide with custom made miniplates presented more accurate clinical results than the thermoplastic guide, but this result is not statistically significant, since it could only be proved, according to the sample calculation performed in the pilot project between the two groups of guides, with a sample of 64 individuals.

For statistical analysis of agreement, the Bland-Altman method was used for each of the three axes (X, Y, Z), using the mean and standard deviation with 95% confidence interval (upper limit +1.96 and lower limit -1.96).

The results of the thermoplastic CAD / CAM guide were: mean X axis of 0.04 and standard deviation of 0.83 and upper confidence interval of 1.66 and inferior of -1.58 mm. In the Y axis the mean was 0.69, the standard deviation of 1.45 with upper confidence interval of 3.55 and inferior of -2.15 mm. In the Z axis the mean was -0.19, the standard deviation of 1.07 with upper confidence interval of 1.86 and lower limit of -2.3 mm.

The results of the titanium guide were: in the X-axis mean of 0.03 standard deviation of 0.84 and upper confidence interval of 1.67 and lower of -1.61 mm. In the Y axis the mean was -0.71, the standard deviation of 1.12 with upper confidence interval of 1.48 and inferior of -2.9 mm. In Z-
axis the mean was -0.33, the standard deviation of 1 with upper confidence interval of 1.63 and lower limit of -2.29 mm

Table 5. Statistical results of the Bland-Altman method

<table>
<thead>
<tr>
<th></th>
<th>Eixo X</th>
<th>Eixo Y</th>
<th>Eixo Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.04 / 0.03</td>
<td>0.69 / -0.71</td>
<td>-0.19 / -0.33</td>
</tr>
<tr>
<td>DP</td>
<td>0.83 / 0.84</td>
<td>1.45 / 1.12</td>
<td>1.07 / 1</td>
</tr>
<tr>
<td>UL</td>
<td>1.66 / 1.67</td>
<td>3.55 / 1.48</td>
<td>1.86 / 1.63</td>
</tr>
<tr>
<td>LL</td>
<td>-1.58 / -1.61</td>
<td>-2.15 / -2.9</td>
<td>-2.3 / -2.9</td>
</tr>
</tbody>
</table>

Abbreviations: G. thermo - Thermoplastic guide; G. Ti - titanium guide; SD - standard deviation; UL - upper limit, LL - lower limit.
Source: Doctor Douglas Voss

3. Discussion

The sample size, methodology and statistics of our work were based on the literature, using similar work on the accuracy of CAD / CAM thermoplastic guides for mentoplasty where 8 and 9 patients were used. 2.16

Our work has two independent samples, we do not have the group with the traditional surgical method, which would be the control group, because one of the inclusion criteria of this prospective study is to operate only asymmetric chin and by the same team; as the team did not operate any asymmetric chin case without using CAD / CAM, this group was not created. Moreover, it is already clear in the literature that guided genioplasty is more accurate and accurate than the conventional method. We chose to study only
the two groups, which is something new in the literature.\textsuperscript{2,13,14,16,17,18} The statistical comparison between the two guides in this study was not feasible, as the necessary sample calculation was performed and the result was 64 samples. Due to the difficulty of obtaining a sample of this size in less than two years, we obtained a total of twenty patients. We lost 4 guides in the surgeries, two thermoplastic guides broke in the region of the fixing holes and two titanium guides were not used because the surgeon aborted its use because he thought that the fixing plate was in the wrong position, probably due to the perforations made using the drill guide were carried out out of the planned position. Therefore these four samples were not used.

The worst results of the two guides were on the Y axis, which represents the anteroposterior direction, probably due to the muscular forces of traction acting in the chin, mainly by the milohyoid muscles, the anterior belly of the digastric, genioglossus and geniohyoid muscles. By this way, the titanium guides and the fixing plate take advantage of it, because due to the rigidity of the material it manages to cancel these forces better.

Surgical planning of chin positioning is essential for optimal symmetry and requires perfect control of three-dimensional rotational movements (X, Y and Z axes). This is undeniably challenging and a crucial issue as it determines clinical success. Surgical accuracy can be better achieved through surgical simulation in a virtual environment using dedicated software and CAD / CAM guides.\textsuperscript{19-20} Analyzing the results, however good they look, we can see that we can improve on some technical details in order to reduce distortions. For example, the quality of the voxels of the tomography, for even using state-of-the-art tomographs with high definition images in the ratio of 1 to 1, the thickness in millimeters of the tomographic cuts influence the resolution of the digital mesh, besides the conversion of the data (multiple algorithms) and the use of different image manipulation software can cause distortions in virtual data up to 0.1 mm.\textsuperscript{21,22} Directly scanning the
teeth with the intraoral arcade scanner has shown superior quality when compared to the scanning of the plaster models. This influences the adaptation of the occlusal guides and also in the moment of the virtual planning. An example of this importance is the overlapping process: by merging the tomography of the patient’s face with the virtual dental models, it is feasible to fail positioning, as it is performed by the software operator in a manual way or in an automated manner by point proximity algorithms, and may influence the final result of the adaptation or precision of surgical splints and templates, especially those that use dental support. The use of a 3D printer for the preparation of surgical guides is a validated method in several studies, with layers smaller than 0.1 mm and has good accuracy, but some research shows that it can present mean distortions of 0.4 mm. The margin of error accepted in some studies of 0.5 mm. Position and angulation of the osteotomies performed in the virtual planning may be different from those performed by the surgeon, even using the cutting guides, which influence their positioning, especially when bone wear is necessary to reposition the chin as in backsliding or intrusion movements. In the search to minimize this type of failure is increasing the number of research on cutting guides and new technologies. The experience and learning curve of the surgeon with the handling of the different "templates" depending on the surgical management can alter the final result, especially in cases of asymmetry, large movements or with extensive bone wear. The surgical technique, with the use of guides, is different from the conventional technique, which is based on intra-oral trans-surgical measures. The CAD / CAM guides have their peculiarities and need training and a learning curve to obtain results with satisfactory accuracy. Titanium, being a metallic material with more rigid characteristics and of greater resistance, allows impressions with reduced measures and details.
more faithfully reproduced. This facilitates its insertion and handling. In addition it assists the positioning of the insertion and angulation of the drill bit, as it does not wear or deform in use. In turn, the thermoplastic guide that is easily worn by the drill and in case the surgeon does not do the correct angulation, the guide wears and accepts the new incorrect position, compromising the precision of the surgery. The resistance of the thermoplastic guides is also inferior to the titanium, and therefore increases the thickness of the guides making them more robust, besides increasing the diameter of the holes, making more passive the entrance of the screw, to avoid, therefore, breaks caused by the fatigue of the material at the time of the handling, drilling with the drills or insertion of the screws.

The main advantage of the thermoplastic guide is the more affordable cost which makes it more used than the titanium guide, as well as the ease of access to 3D printing of this material. The guides with bony support are smaller, more practical and fit well to the anatomy. The critical point of its use is when there is no clarity of its positioning on the bone surface. It is possible to err, especially when there is difficulty in removing the tissue or there is a lack of clarity of the best positioning of the guide on the bone anatomy. In this aspect, the guide with dental support presents better visualization and greater agility of adaptation.

In our work all horizontal basilar osteotomies of the chin were performed in the traditional way with a reciprocating saw and using the CAD / CAM guides. A alternative way is presented in the work of Troedhan A. et.al. (2018) who applied virtual planning in a patient with excess chin used Piezotome (Ultrasound) to wear the anterior portion of the chin without basilar osteotomy, which reduces the risk of soft tissue damage, giving micrometric refinement, smoothing and polishing of the bony edges remaining in the final stage of genioplasty performed with Piezzo drills. The
micrometric and atraumatic precision of the curved Piezotomo osteotomies allowed an accurate transfer of the surgical planning to the execution.\textsuperscript{29}

Hsu S et. al.\textsuperscript{16} in 2013, using a sample of 8 genioplasty using CAD / CAM guides, obtained a mean linear movement of 0.73 mm, concluded that the chin guide is more accurate than the conventional method (1.63 mm) and that it decreases surgical time and increases the cost. Other authors used a sample of 9 patients with mentoplasty with CAD / CAM guides and obtained a mean in the linear method of 0.6 mm.\textsuperscript{2} Analyzing these results, it is verified that they are very similar to those found in our study, presenting mean differences of 0.3 mm.

In 2017, Li B. et al.\textsuperscript{27} using thermoplastic CAD / CAM guides with dental support and fixation with custom titanium plates obtained the following results: 0.74 mm and 1.93 for the maxilla, 1.10 mm and 2.82 for the mandible. The results of the study indicated that the use of this system is accurate and capable of successfully transferring the surgical planning without the use of surgical splints. Mazzoni S. et al.\textsuperscript{18}, in 2015, using the Overlap errors method and precision parameter <2mm, in a sample of 10 patients, obtained an average of 92.7% of the results below 2 mm of movement in orthognathic surgeries with customized fixation miniplates. Using the same parameters of the methodology of this study, we obtained the mean result of 91.7% of the results below 2 mm in a sample of 8 patients.

We would like to point out that our work presenting the accuracy of titanium CAD / CAM guide with custom titanium fixation plate in genioplasty is unprecedented. No patient presented paresthesia, postoperative infection or had to intervene again. Patients were satisfied with the results obtained. Both types of guides generated by CAD / CAM used in this work showed good accuracy with mean linear movement of 1.05 and 0.83 mm respectively, considering that in this work, movements <2 mm are acceptable.\textsuperscript{11,26,28} Some studies consider movements less than 1 mm as a reference, a current
trend, thanks to improvements in materials, designer, virtual planning, softwares and surgical protocols$^{2,18,30}$

4. Conclusion

The thermoplastic and titanium CAD / CAM guides are reliable methods for the genioplasty, demonstrating good accuracy when presenting linear mean movement respectively of 1.05 and 0.83 mm.
References


