

Bolton analysis in a specific program for orthodontics: NemoCast in comparison with free access programs: Meshmixer and 3d slicer

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Abstract

Objective: To analyze and compare the results obtained from the Bolton Total and Partial analysis, in the specific orthodontic software in comparison with the results obtained from the open access software.

Materials and Methods: Data from 49 people who met the exclusion and inclusion criteria were evaluated. The mesiodistal measurements of the dental pieces of the participants were taken in the following programs: NemoCast, MeshMixer and 3D Slicer, after which the calculation of the Bolton Total and Bolton Partial analysis was performed, the data were entered into a database, and then comparative tables were made in the excel program, and the results between the three programs were directly evaluated.

Results: According to the direct True or False analysis method, the tables and graphs presented show that there is a discrepancy between the results of the NemoCast, MeshMixer and 3D Slicer programs, with the latter two having the closest values, and the values with the greatest difference belonging to NemoCast and MeshMixer.

Conclusion: The results show that the analysis of the 3 software programs shows that the averages present similar values with a result higher than 78% for the 3 cases. However, there are differences in the review of the individual results and comparisons of the records one by one and this is due to the data entry procedure.

Keywords: Bolton; Nemocast; Meshmixer; 3D Slicer; Orthodontics; Permanent dentition

1. Introduction

Currently, technology has advanced by leaps and bounds, this is reflected in dentistry where the digital flow is no longer a privilege, but a necessity in day-to-day consultation. The latest advances in digital radiography, intraoral scanners, CBTC, and custom orthodontic appliances have increased the effectiveness and efficiency of treatment outcome. Recent developments have led to rapid growth in digital education, teaching tools, 3D video, and patient interaction (1). The growing popularity of intraoral scanning has opened up new avenues for planning, designing, and executing orthodontic treatment for our patients (2).

Along with the previously mentioned advances, different software has appeared to take advantage of these technologies, some being specific for the area of dentistry (NemoCast) and others being non-specific and freely accessible software (Meshmixer, 3d slicer).

The importance of this study lies in knowing if there was validity, both in the digital measurement of both the specific software for orthodontics (Nemocast), and the free access software (Meshmixer, 3d slicer).

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Bolton's analysis helps us to diagnose and thus to plan orthodontic treatment. Bolton analysis calculates the relationship between the mesiodistal widths of the maxillary teeth and those of the mandibular teeth by using a formula created by Dr. Wayne A. Bolton, which shows if there is a discrepancy in size between the upper and lower teeth. This analysis is used in the permanent dentition, after the eruption of all permanent teeth. This provides the orthodontist with a diagnostic tool to study how to achieve an "ideal occlusion" with an ideal overbite and overbite (3).

This analysis can be obtained in 2 ways in which the first is the total relationship (fig 1) and the second is the previous relationship (fig 2). The total ratio calculated between the two arches is the percentage ratio between the length of the mandibular arch and the length of the maxillary arch. We took out the mesiodistal width of twelve maxillary teeth and the mesiodistal width of twelve mandibular teeth. The percentage is obtained by dividing the sum of the mandibular teeth by the maxillary teeth (3).

$$\text{RADIO TOTAL} = \frac{\text{Suma mandibular 12}}{\text{Suma mandibular 12}} \times 100$$

Figure 1 Total Bolton formula

If the overall ratio is less than 91.3%, it indicates that there is excess maxillary dental material. The maxillary teeth are relatively large compared to the mandibular ones (3).

To obtain the anterior relationship between the two arches, it is the percentage relationship between the mandibular anterior width and the maxillary anterior width. We measure the mesiodistal width of six maxillary anterior teeth (canine to canine) and the mesiodistal width of six mandibular anterior teeth, obtaining the percentage of dividing the six mandibular anterior teeth for the maxillae (3).

$$\text{RADIO ANTERIOR} = \frac{\text{Suma mandibular 6}}{\text{Suma mandibular 6}} \times 100$$

Figure 2 Partial Bolton formula

If the anterior ratio is less than 77.2%, it indicates a maxillary anterior excess; if the anterior ratio is greater than 77.2%, it indicates an anterior mandibular excess (3).

NemoCast is an orthodontic software that allows from the analysis of digital models, diagnosis, digital planning, to the printing of products and presentation of cases to the patient with very useful tools for the orthodontist. This software has a great series of advantages such as the multi-device connection for recording (intraoral scanner), orientation, socketing, and segmentation of models, model analysis, generation of discrepancy reports, creation of treatment plans or setups (simulation of the sequence of movements of the teeth) for aligners or indirect bonding of brackets, intuitive tools for carrying out the set up: mini odontogram to show or extract teeth, automatic symmetry, measurement of interdental contacts and stripping planning, occlusion analysis with articulator virtual, panel with the evolution of the setup (animation of the aligner sequences), orthodontic mockup, printing of biomodels for aligners and indirect cementation splints, etc (4).

Meshmixer is free, open source software from AutoDesk. It is one of the leading programs for preparing CAD files, such as .STL and .OBJ files. MeshMixer offers a large variety of different tools to correct and enhance models for 3D printing. So we can use it to prepare dental 3D models from intraoral or desktop scanners. A 3D model can be very useful for printing a diagnostic 3D model, a 3D model to check the fit of a splint, or an invisible orthodontic model (5).

The objective of this article is: To analyze and compare the results obtained from the Bolton analysis in the specific orthodontic software in comparison with the results obtained from free access software.

2. Material and methods

It is a comparative cross-sectional study. The universe was made up of 40 students of the 7th cycle "B" of the Faculty of Dentistry of the University of Cuenca from the academic period September 2022 - February 2023. A sample made up of

39 students who met the inclusion and exclusion criteria was obtained. Within the inclusion criteria we have: Digital models: That denote a good scanning and digitization resolution. and in Participants: That all participants have uploaded their Bolton analysis carried out in the three different programs corresponding to Nemocast, Meshmixer and 3D Slicer to the database.

Exclusion criteria: Digital models: Models that present a file defect in the software, either in one of the pairs or in the pair of models itself. Models with changes or modifications caused by previous manipulations and in Participants: Participants who do not have their Bolton analysis in the three different programs corresponding to Nemocast, Meshmixer and 3D Slicer to the database.

The hypothesis of this article is based on the fact that there is no difference between the results of the Bolton analysis obtained in the different programs.

2.1. Study variables

Table 1 Study variables

Variable	Concept definition	Indicator	Scale
Total Bolton Analysis	It is calculated by dividing the sum of the mesiodistal widths from the mandibular right first molar to the left first molar by the sum of the mesiodistal widths from the maxillary first molar to the first molars, where the average of the anterior ratio is 91.3.	NemoCast 3D	_%
		3D Slicer	_%
		MeshMixer	_%
Partial Bolton Analysis	It is calculated by dividing the sum of the mesiodistal widths of the six mandibular anterior teeth by the sum of the mesiodistal widths of the maxillary anterior teeth and then multiplying the result by 100. The average of the anterior ratio is 77.2.	NemoCast 3D	_%
		3D Slicer	_%
		MeshMixer	_%

2.2. Methodology

2.2.1. Calibration

The calibration of the digital models was carried out manually and personally by each person belonging to the study in the MeshMixer and 3D Slicer programs, that is, in the free access programs, as for the NemoCast 3D program, the measurement is carried out automatically.

2.2.2. Model coding

Once the respective authorizations were obtained, a database was filled out on the Google Drive platform, with the names and surnames of the participants, in which the result of the total Bolton analysis and the Partial Bolton analysis were placed in the same way in the three programs.

In order to maintain respect for patients, a fundamental bioethical situation, and management of the confidentiality of the information, authorization was obtained from the participants to have access to this database and, in the same way, the names will not be shown in this study.

2.2.3. Measurement of models

The mesiodistal width of the dental pieces was measured in the digital model, with the different tools of each program. In NemoCast (fig 3) the results are obtained automatically (fig 6), while in MeshMixer (fig 4) and 3D Slicer (fig 5) are obtained manually.

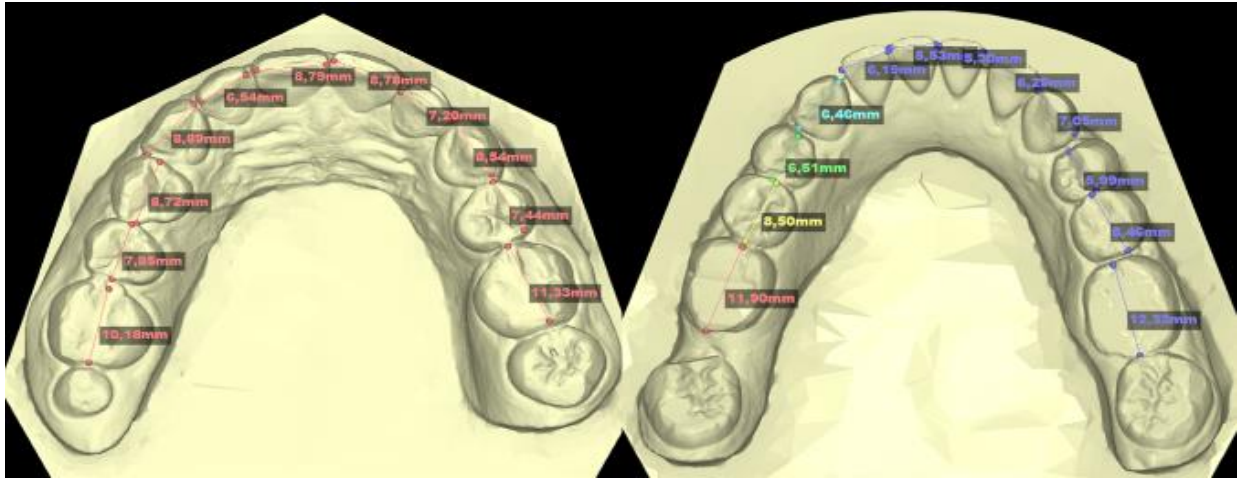


Figure 3 Screenshot of measurement in the NemoCast 3D program

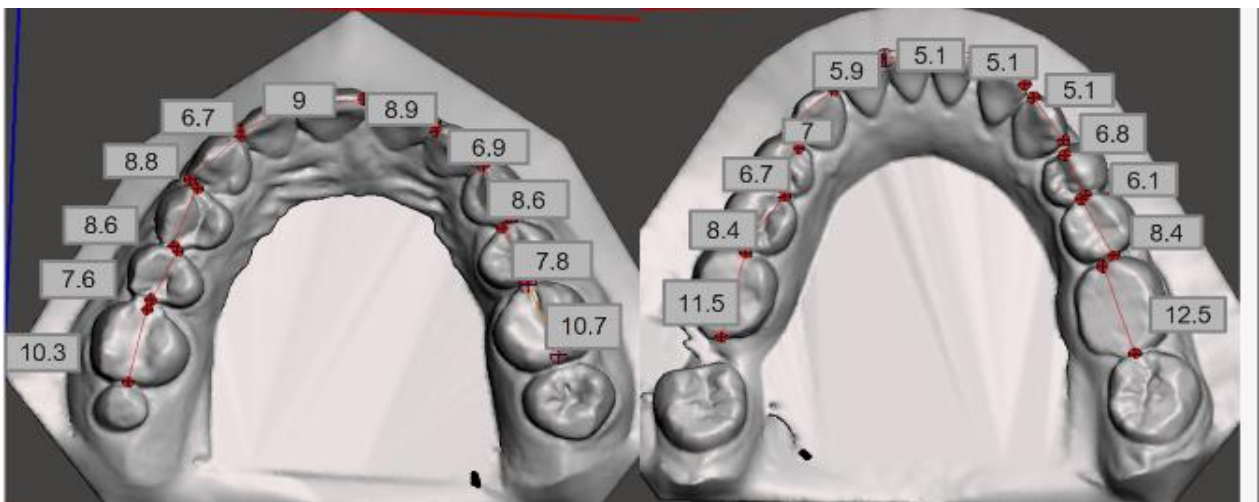


Figure 4 Screenshot of measurement in the MeshMixer program



Figure 5 Screenshot of measurement in the 3D Slicer program



Figure 6 Screenshot of an example of automatically obtaining the values in the NemoCast program

Total Bolton analysis

The operation was performed.

$$\text{RADIO TOTAL} = \frac{\text{Suma mandibular 12}}{\text{Suma mandibular 12}} \times 100$$

Figure 7 Formula of the Bolton Total analysis

Bolton Analysis Anterior

The operation was performed.

$$\text{RADIO ANTERIOR} = \frac{\text{Suma mandibular 6}}{\text{Suma mandibular 6}} \times 100$$

Figure 8 Formula of the Bolton Anterior analysis

2.3. Statistical and analysis methods

2.3.1. Calibration

For the analysis, the following data was recorded: Name, Total Bolton and Partial Bolton of the 3 programs (Nemocast, Meshmixer, 3D slicer) in Excel tables. The data corresponding to partial bolton and total bolton were separated into two different tables.

2.3.2. Measurement comparison

For comparison, in each of the tables corresponding to total Bolton and Partial Bolton, a direct comparison was made between nemocast-meshmixer; meshmixer-3D slicer and 3D slicer-nemocast to analyze if the corresponding data matches between the different programs, marking as FALSE (in the case of not matching) and TRUE (in the case of matching). Subsequently, dynamic tables were prepared with the results to design graphics for subsequent interpretation.

Table 2 Comparison of Bolton values in the 3 programs

NEMOCAST	NEMOCAST-MESHMIXER	MESHMIXER	MESHMIXER-3D SLICER	3D SLICER	3D SLICER-NEMOCAST
BOLTON PARCIAL		BOLTON PARCIAL		BOLTON PARCIAL	
72,75%	FALSO	82,93%	FALSO	77,93%	FALSO
79,08%	FALSO	79,11%	FALSO	75,58%	FALSO
86,51%	FALSO	85,33%	FALSO	86,51%	VERDADERO
76,95%	FALSO	84,58%	FALSO	81,22%	FALSO
76,00%	FALSO	77,00%	FALSO	76,00%	VERDADERO
79,00%	FALSO	73,63%	FALSO	78,24%	FALSO
70,86%	FALSO	70,19%	FALSO	70,49%	FALSO
78,80%	VERDADERO	78,80%	VERDADERO	78,80%	VERDADERO
79,86%	FALSO	77,20%	FALSO	79,00%	FALSO
81,20%	VERDADERO	81,20%	VERDADERO	81,20%	VERDADERO
78,05%	FALSO	77,82%	FALSO	75,30%	FALSO
79,06%	FALSO		VERDADERO		FALSO
80,43%	FALSO		VERDADERO		FALSO
77,20%	FALSO	80,79%	FALSO	74,01%	FALSO
63,34%	FALSO	64,34%	FALSO	63,34%	VERDADERO
83,00%	FALSO	84,60%	FALSO	91,00%	FALSO
81,55%	FALSO	75,80%	FALSO	72,00%	FALSO
83,04%	FALSO	83,01%	FALSO	83,04%	VERDADERO
78,98%	FALSO	81,34%	FALSO	78,98%	VERDADERO
90,66%	FALSO	91,66%	FALSO	90,26%	FALSO
77,20%	FALSO	91,27%	FALSO		FALSO
74,88%	FALSO	72,70%	FALSO	78,22%	FALSO
75,00%	FALSO	86,60%	FALSO	74,97%	FALSO
75,35%	VERDADERO	75,35%	VERDADERO	75,35%	VERDADERO
80,70%	FALSO	78,10%	FALSO	83,90%	FALSO
88,02%	FALSO	91,94%	FALSO	89,18%	FALSO
78,85%	FALSO	78,88%	FALSO	84,64%	FALSO
72,55%	FALSO	75,50%	VERDADERO	75,50%	FALSO
77,20%	FALSO	77,40%	FALSO	77,20%	VERDADERO

76,90%	FALSO		VERDADERO		FALSO
75,21%	FALSO	82,60%	FALSO	82,78%	FALSO
81,81%	VERDADERO	81,81%	VERDADERO	81,81%	VERDADERO
78,51%	FALSO	78,81%	FALSO	77,18%	FALSO
79,50%	FALSO	126,30%	FALSO	80,87%	FALSO
75,10%	FALSO	71,03%	FALSO	70,95%	FALSO
72,15%	VERDADERO	72,15%	FALSO	71,15%	FALSO
79,63%	FALSO	88,96%	FALSO	84,69%	FALSO
78,91%	FALSO	78,67%	FALSO	75,82%	FALSO
79,86%	FALSO		VERDADERO		FALSO
79,71%	VERDADERO	79,71%	VERDADERO	79,71%	VERDADERO

Blank spaces (corresponding to 1 person of the 40 students) were not taken into consideration for the total analysis.

It is important to mention that the data was analyzed with decimals since when considering them as whole units the information would be biased.

3. Results and discussion

3.1. Average of results in the different programs

Table 3 Bolton Total values grouped for the 3 programs

NEMOCAST	MESHMIXER	3D SLICER
BOLTON TOTAL	BOLTON TOTAL	BOLTON TOTAL
86.48%	94.73%	84.69%
91.79%	91.50%	92.26%
96.09%	95.50%	98.24%
88.93%	95.63%	94.17%
92.60%	92.00%	92.00%
94.00%	90.16%	95.11%
does not apply	does not apply	does not apply
95.40%	95.40%	95.40%
91.80%	91.60%	91.60%
93.80%	93.80%	93.80%
96.42%	95.13%	93.56%
89.91%		
93.15%	97.14%	96.59%
91.30%	85.02%	88.33%
92.15%	92.15%	92.15%
95.55%	95.78%	98.00%

92.33%	95.40%	93.30%
94.69%	94.71%	94.57%
91.87%	94.34%	91.87%
82.28%	82.28%	84.28%
91.30%	77.10%	77.10%
95.73%	94.14%	93.70%
91.30%	90.61%	88.20%
91.44%	91.40%	91.40%
93.05%	91.25%	95.40%
86.72%	82.81%	98.35%
92.58%	92.02%	92.26%
87.80%	94.30%	95.50%
91.30%	91.10%	91.40%
92.30%	92.31%	92.31%
89.01%	91.76%	91.68%
93.40%	93.40%	93.40%
95.34%	95.24%	94.69%
86.56%	108.40%	95.26%
70.75%	87.09%	86.80%
89.40%	89.40%	89.40%
90.39%	95.79%	86.72%
95.54%	96.95%	94.25%
91.80%	91.60%	91.60%
94.29%	94.25%	94.25%
91.30%	92.45%	92.20%

As can be seen in Table 3, the averages do not have a significant difference; however, the average of the MESHMIXER results with the average of 3D SLICER has a greater similarity than comparing them with the NEMOCAST program.

This could be due to the fact that the MESHMIXER and 3D SLICER programs share part of the process corresponding to the measurement of the mesiodistal widths of the dental pieces manually in comparison to the NEMOCAST program which is automatic.

The problem with manually entering information as is the case with MESHMIXER and 3D SLICER is that biases can be generated, as indicated in the Harvard article, "Mock your own biases" written by Jack B. Soll, Katherine L. Milkman and John W. Payne, where it is detailed that a cognitive bias is a systematic error in people's thinking and as a consequence of these biases it is dangerous to rely on perceptions or associations stored in our memory(6).

3.1.1. *Partial Bolton*

The results shown in Table 4 the values in green are the averages of the values, which shows an approximation between the results of NEMOCAST and 3D SLICER; however, the three programs are very close, which will not create alterations in the diagnoses

Table 4 Pooled Partial Bolton values of the 3 programs

NEMOCAST	MESHMIXER	3D SLICER
BOLTON PARCIAL	BOLTON PARCIAL	BOLTON PARCIAL
72.75%	82.93%	77.93%
79.08%	79.11%	75.58%
86.51%	85.33%	86.51%
76.95%	84.58%	81.22%
76.00%	77.00%	76.00%
79.00%	73.63%	78.24%
70.86%	70.19%	70.49%
78.80%	78.80%	78.80%
79.86%	77.20%	79.00%
81.20%	81.20%	81.20%
78.05%	77.82%	75.30%
79.06%		
80.43%	72.27%	79.89%
77.20%	80.79%	74.01%
63.34%	64.34%	63.34%
83.00%	84.60%	91.00%
81.55%	75.80%	72.00%
83.04%	83.01%	83.04%
78.98%	81.34%	78.98%
90.66%	91.66%	90.26%
77.20%	91.27%	91.27%
74.88%	72.70%	78.22%
75.00%	86.60%	74.97%
75.35%	75.35%	75.35%
80.70%	78.10%	83.90%
88.02%	91.94%	89.18%
78.85%	78.88%	84.64%
72.55%	75.50%	75.50%
77.20%	77.40%	77.20%
76.90%	76.90%	76.90%
75.21%	82.60%	82.78%

81.81%	81.81%	81.81%
78.51%	78.81%	77.18%
79.50%	126.30%	80.87%
75.10%	71.03%	70.95%
72.15%	72.15%	71.15%
79.63%	88.96%	84.69%
78.91%	78.67%	75.82%
79.86%	72.20%	79.40%
79.71%	79.71%	79.71%
78.33%	80.47%	79.08%

3.1.2. Percentage of agreement between the results Bolton Partial

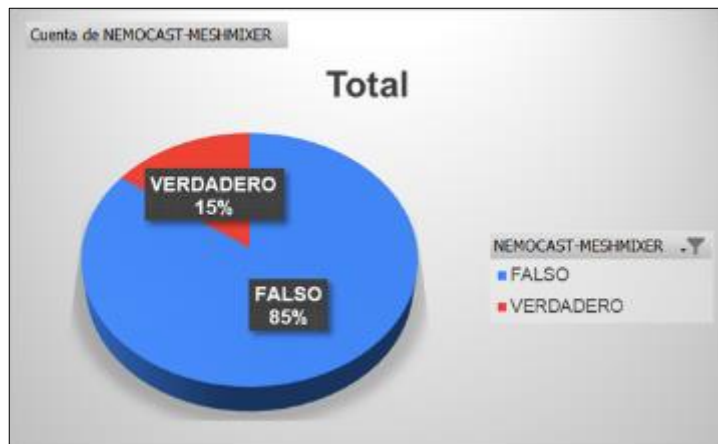


Figure 9 Matches between NEMOCAST and MESHMIXER

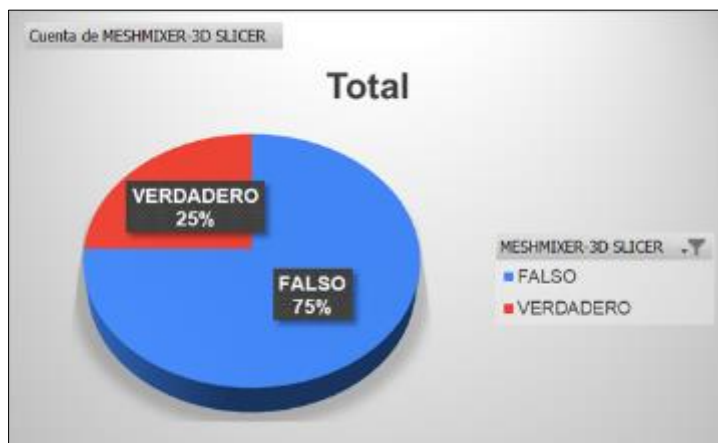


Figure 10 Matching between MESHMIXER and 3D SLICER



Figure 11 Matching between 3D SLICER and NEMOCAST

As can be seen in the graphs, the percentage of no match (FALSE) predominates, which can be interpreted to mean that there are significant differences in the results of the majority of students among the 3 programs analyzed, with the greatest variation between the NEMOCAST and MESHMIXER programs.

3.1.3. *Percentage of coincidence between results Bolton Total*



Figure 12 Matches between NEMOCAST and MESHMIXER

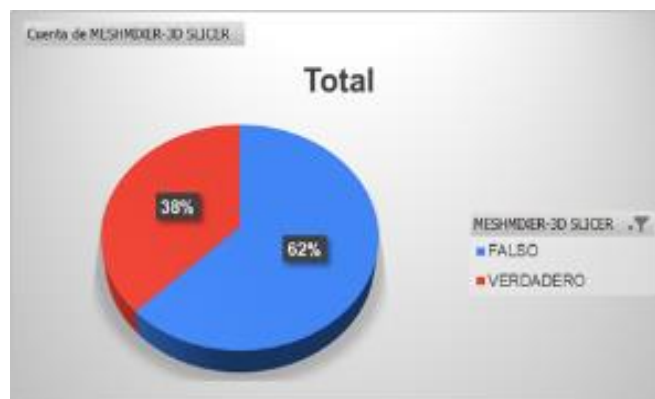


Figure 13 Matches between MESHMIXER and 3D SLICER

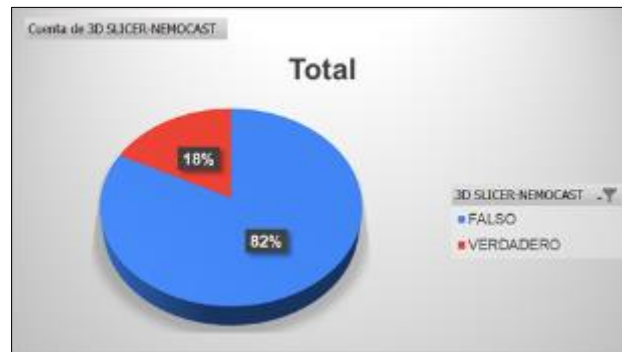


Figure 14 Matching between 3D SLICER and NEMOCAST

It can be seen that the percentage that continues to predominate is FALSE. The programs that coincided the most between their partial Bolton results were MESHMIXER and 3D slicer.

4. Conclusion

Once the analysis of the three software used for the analysis of orthodontic cases has been completed, it can be concluded that the averages present similar values with a result higher than 78% for the three cases (no statistically significant differences). It can be concluded that the averages present similar values with results above 78% for the three cases (no statistically significant differences). However, there are differences in the review of the individual results and comparisons of the records one by one and this is due to the data entry procedure.

For this reason, it is considered that there are differences, although minimal, in the results obtained. The NEMOCAST program is the most efficient because it reduces the margin of error in the entry of information by performing a calculation automatically, without human interaction, this program has a specialized algorithm in the calculation of the required variables, therefore, despite having a lower percentage of similarity with the rest of the programs, from our perspective it is the program that has the highest degree of reliability.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors mention not having any conflict of interest.

Statement of ethical approval

The present research work does not contain any studies performed on animals/humans subjects by any of the authors.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

References

- [1] Nathasha MM, Chakravarthi NCS, Srinivasan D, et al.. Orthodontics in the era of digital innovation – a review. J Evolution Med Dent Sci [Internet] 2021 [consultado 12 Ene 2023] ;10(28): 2114-2121, Disponible en: DOI: 10.14260/jemds/2021/432
- [2] Christensen LR. Digital workflows in contemporary orthodontics. APOS Trends Orthod [Internet] 2017 [consultado 12 Ene 2023] ;7:12-8. Disponible en: DOI: 10.4103/2321-1407.199180

- [3] Andrade M., Aguilar E., Bravo M. Análisis de Bolton en modelos de pacientes y relación con las diferentes Maloclusiones. Revista Latinoamericana de Ortodoncia y Odontopediatría. [Internet] 2014 [consultado 12 Ene 2023]. Disponible en: https://grado.ucuenca.edu.ec/pluginfile.php/1012690/mod_resource/content/1/art12.pdf
- [4] NEMOTEC. NEMOCAST [Internet]. [consultado 12 Ene 2023]. Disponible en: <https://www.nemotec.com/es/software/nemocast>
- [5] Smileep. Tutorial de Meshmixer: edición de archivos STL de un escáner intraoral para imprimir en 3D un modelo ahuecado. [Internet]. [consultado 12 Ene 2023]. Disponible en: <https://smileep.com/meshmixer-tutorial-stl/>
- [6] Jack B. Soll, Katherine L., Milkman y John W. Payne. Burla tus propios sesgos. 1ra Edición. Tulín, Italia:INCAE Business School.2015