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Position accuracy of short abutment analogs in the working model splinted with dental floss versus Bis-acryl bars in total edentulous mandibles

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ABSTRACT

Objective: To compare *in vitro* the positional accuracy of short abutment analogs splinted with dental floss versus short abutment analogs splinted with Bis-acryl bars as a preliminary step to obtaining the working model in the preparation of implant-supported prostheses in total edentulous mandibles. **Materials and methods**: An aluminum master model simulating an edentulous mandible with five analogues was prepared. Using a customized tray and, by means of a technique for fixing the transfers to it, thirty impressions were recorded, which were divided into three groups: WS group (without splinting), SDF group (splinting with dental floss) and SBB group (splinting with bis-acryl bars). Subsequently, a digital indoor micrometer was used to perform distance and height measurements between analogs. The statistical tests used were Shapiro-Wilk, ANOVA and Tukey's *post hoc*. **Results:** For distance measurements, no statistically significant differences were found between groups ($p = 0.674$). For height, statistically significant differences were found between groups ($p < 0.001$). Bis-acryl presented differences with the WS and SDF groups ($p < 0.001$). **Conclusions:** Splinting of short abutment analogs did not show significant differences in the distance measurement; however, it did present differences in the height measurement, specifically between the SBB and WS groups, as well as between SBB and SDF groups.

Keywords: dental implants; dental prosthesis; dental impression techniques; dental floss.

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INTRODUCTION

The surgical protocol proposed by Branemark determines the basis of osseointegration implant surgery. These precepts aim to achieve the best biological conditions to promote implant osseointegration (1). After the surgical procedure, the prosthetic phase takes place, in which a definitive impression is made. Impression is defined as a negative image or reverse copy of the surface of a body. In implant prosthetics, it is also called transfer. In addition, there is standardization of the components used for this purpose, since we know the dimension of the platform of the implant placed, which presents a perfectly adequate impression component called transfer (2, 3).

Transfer is the element of an implant system used to provide the spatial relationship between an endosseous dental implant and the alveolar ridge, as well as the dentition or other adjacent structures. Also named impression copings, these can be trapped in the impression or require manual transfer or repositioning. They are used intraorally for the impression record and then the analog or replica is attached to it (2, 3). This is how the abutment platforms in the patient's mouth are emulated by means of analogs in a structure made of plaster, which must faithfully reproduce their three-dimensional location. Gallucci et al. (4) used impressions made in eleven edentulous segments with the open and closed tray technique, without finding a significant difference between them. However, Nakhaei et al. (5) compared these techniques and found the open-tray impression technique to be the most accurate.

There are certain factors that alter the obtaining of accurate study models, such as the dimensional changes of the plaster during setting and the inadequate selection and handling of the impression material (6-10). An accurate working model will provide passive settlement of the metal framework, avoiding mechanical failure and biological complications around the implants (11-16). Currently, several techniques have been suggested for the splinting of transfers, prior to casting, which would improve the accuracy in the reproduction of the location of the abutments in the working model (12). The splinting technique stabilizes the copings during impression to prevent rotational movements and, in turn, reduce the dimensional changes caused by the impression material in the model making process (12, 13). Regarding complete edentulous situations with 4 or more implants, splinted impressions have been shown to be more accurate than unsplinted impressions (14, 17-21). A low shrinkage resin can be used for splinting, mainly indicated for precision soldering procedures (20, 21). Similarly, self-curing resins with high flexural strength can be used, indicated for the fabrication of long-lasting temporary resins (19, 22, 23).

Considering that the impression technique with transfer splinting offers high accuracy in the fabrication of implant prostheses compared to impression techniques without splinting, it is important to mention that previous evidence on the splinting of analogs prior to casting the working model is scarce. Therefore, the aim of this study was to compare *in vitro* the positional accuracy of short abutment analogs splinted with dental floss versus short abutment analogs splinted with Bis-acryl bars, as a preliminary step to obtaining the working model in the fabrication of implant-supported prostheses in total edentulous mandibles.

MATERIALS AND METHODS

For this *in vitro* study, 30 working models of total edentulous mandibles were made in plaster type IV (Elite Dental Stones®, Zhermack SpA, Rovigno, Italy), following all technical specifications of the Branemark Protocol, randomly distributed in three groups (n = 10): without splinting (WS) (as a control group for comparison of the groups under evaluation), splinting with dental floss (SDF), and splinting with Bis-acryl bars (SBB) (Figure 1). The sample size was selected on a non-probabilistic basis.

Figure 1. Analog splinting techniques. A) group without splinting (control group); B) group splinted with dental floss (SDF); C) group splinted with Bys-acryl bars (SBB).

The pattern model of the lower mandible was designed to simulate an edentulous mandible with multiple implants, representing a hybrid prosthesis on implants, since this type of prosthesis presents greater challenges during the transfer impression (Figure 2). Miniabutment analogs were placed in the standard model, following a specific distribution: The distal analogs were located 2 mm in front of the position of the mental foramen (A, E). The central analog (C) was located at half the distance of analogs A and E. The fourth analog (B) was located at half the distance of analogs A and C. And the last one (D) was located at half the distance of analogs C and E.

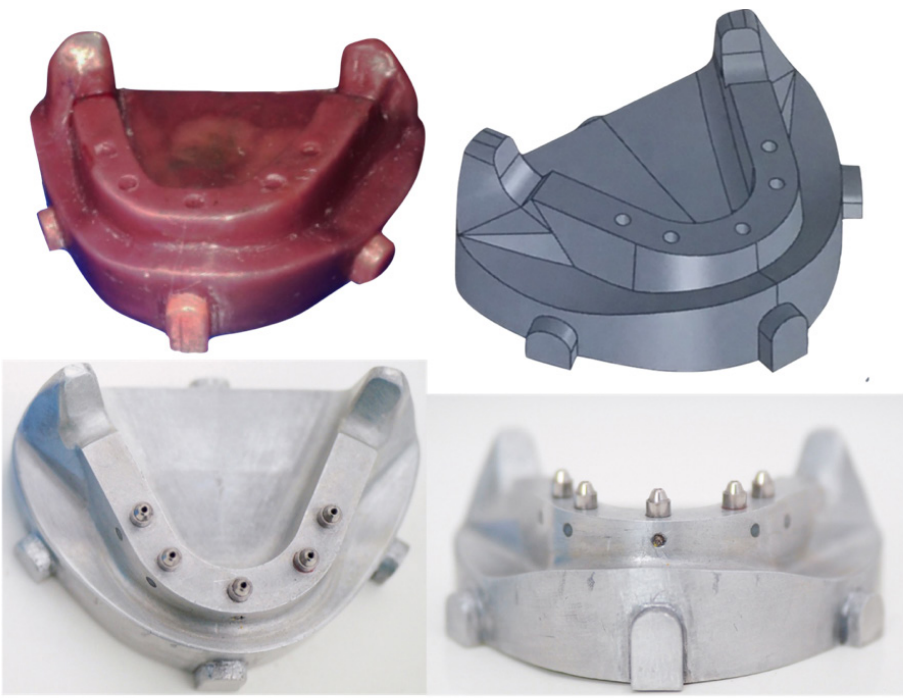

Figure 2. Pattern model scheme and distribution of analogs.

All analogs were placed at right angles between the axial axis with respect to the base of the standard model. The model had four positioning extensions on the anterior, posterior and lateral surfaces of the base, which served to standardize the reproduction processes. A 2 mm thick acrylic tray was made, with perforations to position the transfers and notches to fit the extensions, allowing free space for the impression material to run off.

Tray adhesive was applied, and addition silicone of regular and heavy consistency was used for the impression. Excess material that overflowed was cut with a No. 15 scalpel blade (Surgical Blades Swann

Morton, Shefield, England). Subsequently, the transfers were bonded with acrylic resin (GC Pattern Resin® Low Shrinkage Modelling Resin, Alsip, USA) to the impression tray, and the transfers were unmatched for complete removal of the impression from the pattern model. This procedure was repeated to obtain a total of 30 impressions. The impressions were cast with type IV extradrystalline plaster (Elite Dental Stones®, Zhermack SpA, Rovigno, Italy), using the ratio of 20 mL of water per 100 g of powder, established by the manufacturer in a vacuum mixer (Elite® Mix Zhermack, Polesine, Italy).

The distance measurements between the abutment analogs were performed taking as reference the axial axis of each of the analogs, for which a digital inside micrometer (Digital Inside Micrometer, range: 5-30 mm, Insize, Suzhou, China) was used. The segments in which the measurements were taken were as follows: AB, AC, AD, AE, BC, BD, CD, CE, DE, EB (Figure 3B). For the measurement of the height of each analog, the top of the flange and the highest end of each abutment analog were taken as a reference.

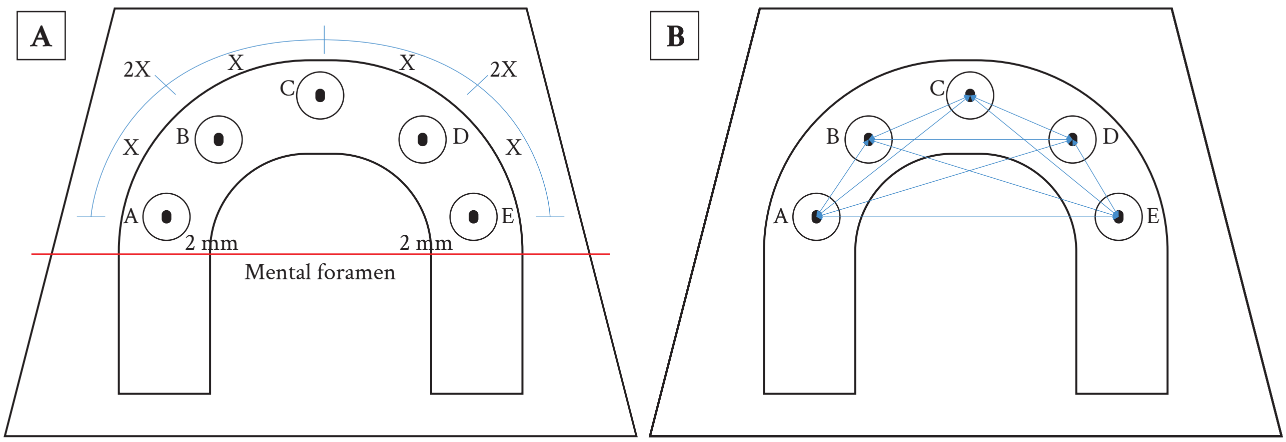

Figure 3. Analogue position scheme. A) Distribution of analogues; B) Measurements made on the standard model.

A descriptive analysis was performed to verify the metric variations of distance and height between the analogs, and the normality of the data was verified with the Shapiro-Wilk test. An ANOVA and Tukey's post hoc statistical analysis was also carried out to contrast the means of the metric variations in distance and height according to the splinting groups, using the SPSS 25.0 statistical program. The study had a confidence level of 95% and a $p < 0.05$. As it was an *in vitro* study, permission was obtained from the University Board of Regulatory Research Affairs of the Universidad Peruana Cayetano Heredia (DUARI-UPCH).

RESULTS

Distance and height values of the three groups are shown in Tables 1 and 2. In terms of distance, the mean of the WS group was 24.914; the mean of the SDF group was 24.929; the mean of the SBB group was 24.921; and the mean of Pattern was 24.925, where no statistically significant differences were found ($p = 0.674$) (Table 1).

Table 1. Distance measurements per segments (in mm).

Segment	Without splinting (WS)			Dental floss (SDF)			Bis-acryl (SBB)			Pattern
	X	SD	Dif.	X	SD	Dif.	X	SD	Dif.	
AB	11.282	0.021	0.000	11.316	0.023	0.034	11.288	0.031	0.006	11.282
AC	26.000	0.029	0.012	26.012	0.033	0.000	26.014	0.031	0.002	26.012
AD	36.248	0.041	0.015	36.292	0.032	0.029	36.287	0.027	0.024	36.263
AE	40.684	0.017	0.019	40.672	0.042	0.007	40.653	0.033	0.012	40.665
BC	16.024	0.026	0.043	16.011	0.036	0.056	16.029	0.026	0.038	16.067
BD	29.300	0.028	0.014	29.320	0.028	0.006	29.314	0.034	0.000	29.314
BE	36.325	0.043	0.016	36.347	0.040	0.009	36.341	0.024	0.003	36.338
CD	16.043	0.024	0.013	16.063	0.020	0.007	16.035	0.035	0.021	16.056
CE	26.024	0.031	0.015	26.032	0.030	0.007	26.016	0.026	0.023	26.039
DE	11.210	0.028	0.006	11.223	0.036	0.007	11.234	0.035	0.018	11.216

X: Mean; SD: Standard deviation; Dif.: Difference with pattern.

In terms of height, the mean of the WS group was 5.188; the mean of the SDF group was 5.176; the mean of the SBB group was 5.214; and the mean of Pattern was 5.179, where statistically significant differences were found ($p < 0.001$).

Table 2. Height measurements per segments (in mm).

Segment	Without splinting (WS)			Dental floss (SDF)			Bis-acryl (SBB)			Pattern
	X	SD	Dif.	X	DE	X	SD	Dif.	X	
A	5.335	0.010	0.007	5.307	0.040	0.035	5.378	0.056	0.036	5.342
B	5.132	0.005	0.027	5.120	0.007	0.015	5.170	0.029	0.065	5.105
C	5.147	0.018	0.040	5.132	0.010	0.025	5.161	0.030	0.054	5.107
D	5.188	0.023	0.005	5.196	0.011	0.013	5.190	0.020	0.007	5.183
E	5.138	0.007	0.025	5.125	0.005	0.012	5.170	0.032	0.057	5.113

X: Mean; SD: Standard deviation; Dif.: Difference with pattern.

When comparing the height groups, the SBB group showed a difference with the WS and SDF groups ($p < 0.001$) (Table 3).

Table 3. Mean distance and height measurements between groups (in mm).

	Without splinting (WS)	Dental floss (SDF)	Bis-acryl (SBB)	Pattern	p
Distance	24.914	24.929	24.921	24.925	0.674*
Height	5.188^{a}	5.176^{ab}	5.214^{ab}	5.170	<0.001*

* ANOVA test.
** Tukey's post hoc test: equal letters represent statistically significant differences ($p < 0.05$).

DISCUSSION

The main objective of the study was to evaluate the positional accuracy of splinted short abutment analogs using two different methods: dental floss and Bis-acryl bars, including a control group without splinting. This step is considered critical in the manufacture of the working model used in implant-supported prostheses for total edentulous mandibles. Precision in the working model is fundamental, as it serves as the basis for the creation of the metal structure. The correct adaptation of this structure is essential to avoid the transmission of harmful forces to the implants, which could lead to both mechanical and biological complications, including the loss of implants in the oral cavity.

In relation to distance, our results revealed no significant differences between the splinted and unsplinted analog groups. However, significant differences were observed in the height dimension, where the splinting material using Bis-acryl showed lower accuracy compared to the splinted group without floss and the unsplinted group. Although we did not find specific papers in the literature that present results on analog splinting, there are investigations on the splinting of transfers that can serve as a reference, since they involve a similar splinting technique. Despite the differences between the procedures, the results of these studies are comparable, since in both cases the aim is to immobilize certain parts of interest.

In this regard, it is relevant to mention the previous studies of Herbst et al. (23), in 2000, who found no significant differences between splinted and unsplinted transfers, as well as the findings of Papaspyridakos et al. (24), in 2012, who stated that the splinting technique led to more accurate plaster models in implant-supported fixed prostheses in edentulous mandibles. Although our study did not reveal significant differences in distance between the groups analyzed, significant differences in height dimension were observed in the group that used Bis-acryl as splinting material, and this discrepancy could be related to the study conducted by De Avila et al. (12), in 2014. These researchers indicated that the use of bur shanks produced excellent results due to the rigidity of the material (stainless steel), which does not undergo expansion or contraction, in contrast to resins, which tend to contract during the polymerization process.

It is important to note that the printing technique used in our study was based on the approach described by Lanis et al. (16), in 2015, where transfers are splinted by attaching them to a customized tray. Despite providing adequate accuracy, this technique has some clinical disadvantages, such as the need to keep the tray in the mouth during fixation of the transfers, which could lead to distortions. This approach is supported by the results of the study by Torres (25), in 2017, who compared various splinting techniques for impressions, including the technique of transfer fixation to the tray, previously described by Lanis et al. (16) in 2015. The findings of Torres (25) suggest that the technique of fixing transfers to the tray with acrylic resin outperforms splinting transfers with acrylic resin-coated dental floss in terms of precision.

The lack of significant difference in the distance between the pattern and the evaluated groups could be explained by an adequate impression technique, which provides the necessary confidence to carry out the subsequent conventional steps without the need to perform additional procedures before pouring the working model. Hoods-Moonsammy et al. (26), in 2014, established a maximum limit of mismatch in passive settlement of the metal superstructure of 0.150 mm before performing the installation of the prosthesis in the mouth. Our study showed that, regardless of the splinting technique used, all groups showed values below this baseline figure.

Considering these results, the question arises as to whether splinting of analogs is a necessary laboratory procedure. This question is aligned with the conclusions of a study carried out by Poquioma (27) in 2016. This author evaluated the splinting of short abutment analogs in the fabrication of total edentulous mandible models using acrylic resin bars and acrylic resin-coated dental floss. Their results indicated that there was no significant difference in distance or height between the groups tested.

No statistically significant differences were observed in the distance segments between the analogs, but significant differences were found in the height dimension, especially in the group that used Bis-acryl as splinting material. This finding could be attributed to exothermic changes during the polymerization process of the material, which are related to the reaction of its vinyl groups. Ha et al. (28), in 2011, suggested that these changes could be related to resin volume. Additionally, a previous study by Kim and Watts (29), in 2004, indicated that the shrinkage coefficient of Bis-acryl Luxatemp Star® (DMG) is in the range of 3.31-3.64%.

Apart from that, the lower precision in splinting could be attributed, particularly in the case of the Bis-acryl bar technique, to the difficulty of this procedure for the operator. This is compounded by the time required to carry it out, which translates into greater effort and, ultimately, higher economic costs due to the limited accessibility of the material. Since Bis-acryl is mainly used in the creation of mock-ups in routine clinical practice, its use in this type of procedure could be considered complicated and even questionable in terms of relevance. Finally, it is relevant to mention the study by Matta et al. (30), in 2017, who reported that the implementation of digital impressions could potentially replace conventional procedures, as it leads to improvements in the accuracy of CAD-CAM fabrication of superstructures.

The *in vitro* nature of the experimental design may not fully reflect actual clinical conditions. In addition, the specificity of the material and models used may limit the generalization of findings. Finally, the splinting technique used may not be fully representative of all clinical practices. Despite these limitations, the study provides valuable information on the accuracy of splinted short abutment analogs, contributing to the knowledge in implant-supported prosthodontics in total edentulous mandibles.

CONCLUSION

Splinting of short abutment analogs did not show significant differences in the distance measurement; however, it did show differences in the height measurement, specifically between the SBB and WS groups, as well as between SBB and SDF.

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