Influence of the implants inclination on the accuracy of the working cast

Influência da inclinação dos implantes na precisão do modelo de trabalho

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Abstract

The aim of this study was to evaluate the influence of the implants inclination on the accuracy of the working cast obtained by two different pouring techniques. A metallic matrix containing two implants, positioned at 90 and 65 degrees in relation to the alveolar ridge, was submitted to the direct transfer impression technique. In CP group (conventional pouring - n=10), the impressions were poured with dental stone type IV using the conventional technique. In EP group (experimental pouring - n=10), the analogs were embraced with latex tubes before the first pouring. After sixty minutes, these tubes were removed and the space was filled with the dental stone. The metallic matrix (control group) and the replicas were evaluated regarding the implant/analog inclination and the vertical misfit between a framework and the implants/analogs. The data were tabulated and analyzed using analysis of variance (ANOVA) and Tukey test at the 0.05 level of significance. Regarding the analog inclination, both experimental groups differed statistically ($p<0.05$) from the control group only in relation to the leaning analogs. Results demonstrated significant difference ($p<0.05$) between the control group and the experimental groups when the reading of the vertical misfit was accomplished in the perpendicular implant/analog with the retention screw in the leaning implant/analog and between the control group and the EP group in the opposite situation. Considering the inclination, perpendicular implants produced more accurate casts independently of the plaster pouring technique.

Uniterms

Prosthodontics; implant-supported; master cast accuracy; pouring technique.

Introduction

Dental implants are an efficient alternative to oral rehabilitation due to the osseointegration that provides an unity among bone, implant and prosthesis[20].

The long term success of the treatment is related to the effective patient home care[17], the appropriate alignment of the implants and their position of implantation[25] and the passive fit of the superstructure to the abutment or the implant. These factors are relevant to provide an adequate distribution of the stress through the implant-bone interface[12,21,22] even though it is impossible to measure the biological capacity of each individual according to different degrees of misfit[8].

This fact is a result of an accurate working cast that shows characteristics such as position and inclination of the implants by the same way they are in the mouth. This accuracy is related to the impression technique[3,9,15,19,24], the dimensional stability and good reproducibility of the impression material[10,26] and the careful plaster pouring considering its expansion[14,23].

Besides the influence generated by the technical steps, another important aspect related to the working cast accuracy less evaluated at the literature is the implants inclination[2,6,7].

Although many studies have shown unfavorable stress distribution to leaning implants[5,25], they are indicated when it is necessary to preserve anatomical structures[13] or according to biomechanical and aesthetics reasons[16,18]. When the position and inclination of the implants are not transferred to the working cast accurately, misfit occurs between the prosthesis and the implant and it is able to damage the support structures and to cause the retention screw loosening or even prosthesis and implant fracture[11].

According to these facts, the aim of this study was to evaluate the influence of the implants inclination on the accuracy of the working cast obtained by two different plaster pouring techniques.

Material and method

For this study, a metallic matrix, similar to a medium toothless jaw was made, in which two implants of 3.75 X 10.0 cm (Master; Conexão Systems of Prosthesis, São Paulo, SP, Brazil) were positioned at 90 and 65 degrees in relation to the alveolar ridge surface (Figure 1).

The matrix was submitted to the direct transfer impression technique with splinted impression squared copings through a dental floss scaffold covered with self-curing acrylic resin (Duralay; Reliance Dental MFG Company, Worth, IL, USA). Twenty individual open trays were fabricated with self-curing acrylic resin (Jet; Artigos Odontológicos Clássico Ltd., São Paulo, SP, Brazil) to perform ten impressions for each experimental group with polyether (Impregum Soft; 3M ESPE, Seefeld, Germany) as the impression material.

All impression procedures were carried out in a controlled temperature (23ºC ± 2ºC) and humidity (50% ± 10%) ambient and the impression material setting was accomplished in a stove at 37ºC ± 2ºC. When the material setting has finished, the screws of the copings were removed with a screwdriver, and the impression/matrix set was separated with the help of a device screwed at the base of the metallic matrix (Figure 2).

FIGURE 1 – Metallic matrix with two implants fixed at 65° and 90° in relation to the alveolar ridge surface with square impression copings.

FIGURE 2 – Internal view of the impression with copings.

The impressions were submitted to pouring techniques that determined two experimental groups (n=10). In one of the experimental groups, the impressions were poured according to the conventional pouring technique (CP group). In the other experimental group, the impression were poured according to a two-times pouring technique named experimental pouring technique (EP group).

For CP group, the implant analogs were adapted and screwed into the copings and, sixty minutes later, the impressions were poured according to the conventional pouring technique. So, dental stone type IV (Durone; Dentsply Indústria e Comércio Ltd., Petrópolis, RJ, Brazil) was manipulated with a vacuum machine (Turbomix; EDG Equipamentos e Controles Ltd., São Paulo, SP, Brazil), with a powder/water ratio of 60g/12ml and then poured under constant vibration into the impression (Figure 3).

For EP group, the implant analogs were placed in natural latex surgical tubes (Auriflex Indústria e Comércio Ltd., São Roque, SP, Brazil), before being adapted and screwed into the copings. Sixty minutes later, dental stone type IV (Durone; Dentsply Indústria e Comércio Ltd., Petrópolis, RJ, Brazil) was manipulated with a vacuum machine (Turbomix; EDG Equipamentos e Controles Ltd., São Paulo, SP, Brazil), with a powder/water ratio of 60g/12ml and then poured under constant vibration into the impression (Figure 4). After sixty minutes, the latex tubes were removed and the space was filled with dental stone type IV with a powder/water ratio of 30g/7ml (Figure 5).

When the material setting has finished (60 minutes later), the impression was separated from the cast in both groups (CP and EP) to obtain the matrix replicas. The metallic matrix was considered as the control group (M group).

Implants/analogs inclination measurement

The metallic matrix implants and the replica analogs, with the coping screws, were scanned (ScanJet 6100 C, Hewlett Packard Company, USA) to produce digitalized images that were carried, online, to the AutoCAD 2005 software (Autodesk, USA). The implant/analog inclinations were determined regarding the upper edge of a glass plate fixed on the scanner lens, to standardize the replicas and matrix position, using the *dimension angular* tool. Each implant/analog inclination measurement was repeated three times (Figure 6).

Vertical misfit measurement between the framework and the implants/analogs

A framework fused into nickel/chrome alloy (CNG soluções protéticas , São Paulo, SP, Brazil) with clinical passive fit to the metal matrix was adapted to each replica and to the metallic matrix with a titanium screw (Figure 7). The screw was tightened using a 10N/cm torque driver (Conexão Systems of Prosthesis, São Paulo, SP, Brazil), firstly to the analog corresponding to the perpendicular implant to the misfit measurement at both analogs (perpendicular and leaning) and, later, with the titanium screw tightened to the analog corresponding to the leaning implant, for the same reading.

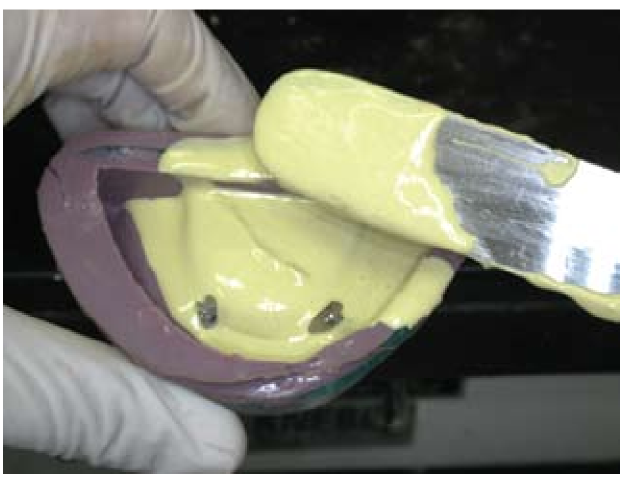

FIGURE 3 – Dental stone pouring under constant vibration (conventional pouring).

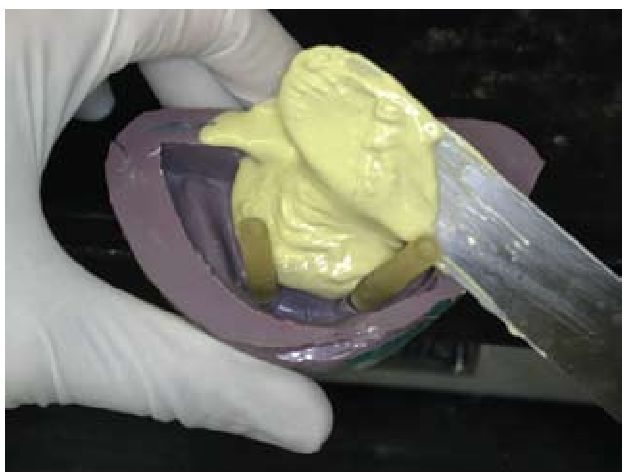

FIGURE 4 – Initial dental stone pouring with latex tubes around the analogs.

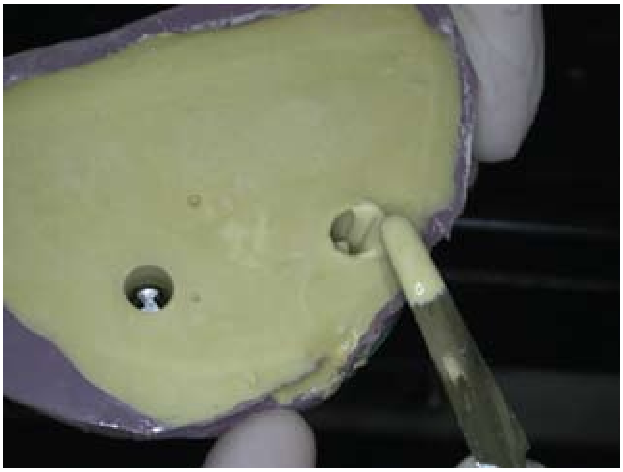

FIGURE 5 – Final dental stone pouring into the space created by the latex tube.

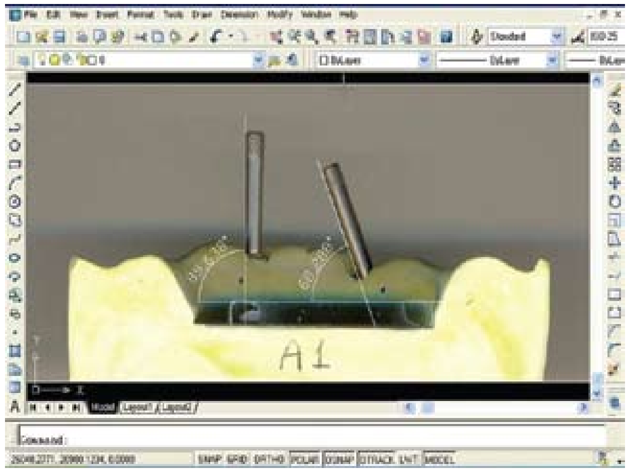

FIGURE 6 – Image of the computer screen after analogs inclination measurement in one of the replicas of CP group through AutoCAD 2005 software (Autodesk - EUA).

FIGURE 7 – Metal framework adapted to the metal matrix.

The gap created between the framework and each implant/analog, in μm, was analyzed using LEICA QWin software (Leica Imaging Systems Ltd., Cambridge, UK) that received the images from a video camera (TK-C1380; JVC, Japan) coupled to a LEICA microscope (LEICA, Germany). Each measurement performed at each implant/analog was repeated three times.

Data obtained with inclination measurements were tabulated and compared among the groups. So, it was performed a 1-way analysis of variance (ANOVA) and Tukey test (α=.05) for the perpendicular implant/analog inclination reading and another similar analysis and test for the leaning implant/analog inclination reading.

Data obtained with vertical misfit were tabulated and analysed using 3-way analysis of variance (ANOVA) and Tukey test (α=.05). The means of vertical misfit measurements were compared regarding the groups, the reading performed at each implant/analog and the retention screw position.

Results

After the implants/analogs inclination measurements, ANOVA just revealed significant difference among the groups (p=0.00010) when the leaning implant/analog readings were considered (Table 1).

Table 1 – ANOVA. for implants/analogs inclination considering the leaning implant/analog reading

Sources of variation	DF	SS	MS	F Value	Prob. > F
Groups	2	3.4721	1.7361	15.9304	0.00010
Residue	27	2.9424	0.1090		
Total	29	6.4145			

The Tukey test revealed significant differences between the M group and the groups CP and EP, which presented similar means, see Table 2.

Table 2 – Tukey test (α=.05) for inclination groups means (degrees) for leaning implant/analog readings

Group	Means
M	69.9290 [a]
CP	69.2300 [b]
EP	69.1870 [b]

* Means followed by the same letter in the column do not differ statistically.

After measurement of the vertical misfit between the framework and the implants/analogs, data were analyzed by ANOVA and demonstrated significant differences among groups (p=0.00001), among readings performed at each implant/analog (p=0.00028) and among retention screw localizations (p=0.00743), both with individual analysis and regarding the interactions among these factors (Table 3).

Table 3 – ANOVA for vertical misfit

Sources of variation	DF	SS	MS	F Value	Prob. > F
Groups	2	56118.5100	28059.2550	17.3034	0.00001
Reading site	1	26347.8825	26347.8825	16.2481	0.00028
Screw site	1	12069.0952	12069.0952	7.4427	0.00743
Group*Reading	2	43603.9071	21801.9535	13.4447	0.00005
Group*Screw	2	14230.9937	7115.4968	4.3879	0.01451
Reading*Screw	1	29026.5632	29026.5632	17.9000	0.00017
Gr*Read*Scr	2	16379.4411	8189.7205	5.0504	0.00816
Residue	108	175132.7541	1621.5996		
Total	119	372909.1468			

Tukey test revealed significant differences of vertical misfit between the readings in the perpendicular and the leaning analogs in both experimental groups (CP and EP) only when the retention screw was at the leaning analog with higher misfit at the perpendicular analog (Tables 4 and 5).

Table 4 – Tukey test (α=.05) for vertical misfit means (μm) of CP group with retention screw in the leaning analog

Reading site	Means
Perpendicular	162.5000[a]
Leaning	22.4430[b]

* Means followed by the same letter in the column do not differ statistically.

Table 5 – Tukey test (α=.05) for vertical misfit means (μm) of EP group with retention screw in the leaning analog

Reading site	Means
Perpendicular	75.4920[a]
Leaning	34.3060[b]

* Means followed by the same letter in the column do not differ statistically.

Tukey test revealed significant differences of vertical misfit exhibited at the perpendicular implant/analog among the three groups when the retention screw was in the leaning implant/analog with the highest mean to the CP group (Table 6).

The vertical misfits at both analogs were similar at groups CP and EP when the retention screw was in the perpendicular analog.

However, Tukey test revealed significant differences between the vertical misfit observed in the leaning implant/analog of the groups EP and M when the retention screw was in the perpendicular implant/analog (Table 7).

Table 6 – Tukey test (α=.05) for vertical misfit groups means (μm) when readings were performed in the perpendicular implant/analog with the retention screw in the leaning implant/analog

Group	Means
CP	162.5000 [a]
EP	75.4920 [b]
M	15.7480 [c]

* Means followed by the same letter in the column do not differ statistically.

Table 7 – Tukey test (α=.05) for vertical misfit groups means (μm) when readings were performed in the leaning implant/analog with the retention screw in the perpendicular implant/analog

Group	Means
EP	61.0300 a
CP	28.6760 ab
M	14.9550 b

* Means followed by the same letter in the column do not differ statistically.

Discussion

The accuracy of the working cast is dependent of the precision obtained during the clinical and laboratorial steps. According to this, several studies have attempted to determine the ideal combination of dental materials and laboratory techniques to produce the most accurate dental cast[4].

It is important to emphasize the correct choice of the impression technique according to each case at clinical phase. In this study, it was applied the direct transfer impression technique with splinted impression squared copings with acrylic resin because of its accuracy with parallel[3,9,15,19,24] and non parallel[6] implants instead of the indirect technique.

The impression material must exhibits characteristics such as flexibility, adequate reproducibility and dimensional stability to avoid distortions. According to these characteristics, it was utilized polyether as impression material due to its rigidity and stability in comparison to other materials[2].

The pouring procedure can alter the analogs relationship because of the plaster expansion. So, the selection of the type of gypsum product for casts is dependent on the purpose for which the replica is to be used. Accuracy and dimensional stability over time are properties of concern in implant prosthodontics. In order to minimize this factor, type IV dental stone is used for making working casts because of its high strength and low expansion[1].

Besides the selection of the type of dental stone, the present study accomplished a two-times pouring technique creating a reduced space around the analogs with latex tubes according to the theory that less material causes less expansion[14]. This can be an advantage because the passivity of a prosthesis on the master cast may not be reflected as passivity intraorally when the master cast does not reproduce accurately the intraoral relationships[26].

However, the results showed that only the leaning analog exhibited significant difference in relation to its inclination independent of the pouring technique (Tables 1 and 2). In the study of Brosky et al. (2002), the pouring technique did not affect the accuracy of final cast too. According to this it is possible to observe that the implant inclination influences the accuracy of the analog position. The same finding was observed by Assunção et al. (2004) when perpendicular implants resulted in more accurate casts.

This alteration can be explained by the physical principle which affirms that the force applied on a body is directly proportional to the area exposed to this force. When the impression is totally recovered by the plaster, an upper area of the leaning analog is exposed to vertical forces in comparison to the perpendicular analog. The higher quantity of plaster above the leaning analog results in a higher force than that applied above the perpendicular analog as figure 8 shows. All these forces probably moved the leaning analog (Figure 9) and resulted in the decrease of the angle at its mesial portion (Table 2).

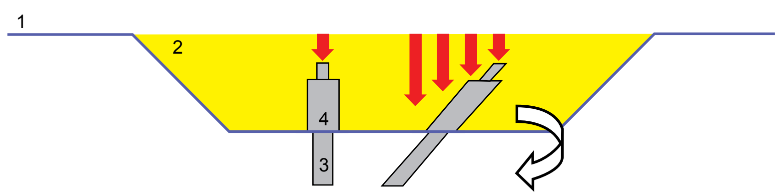

FIGURE 8 – Representation of the impression (1) after plaster (2) pouring with the impression squared copings (3) and the analogs (4) submitted to vertical forces represented by the red arrows.

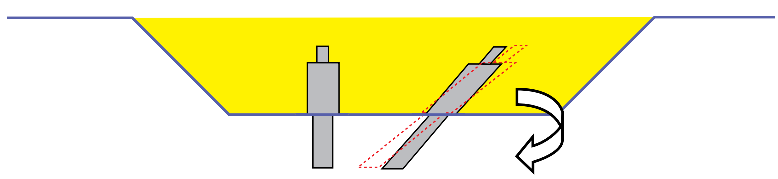

FIGURE 9 – Representation of the leaning analog movement after vertical forces action.

The positional alteration of the leaning analog resulted in the vertical misfit observed in the perpendicular analog when the retention screw was in the leaning analog in groups CP and EP (Tables 4 and 5). All groups revealed significant difference related to the vertical misfit showed in the perpendicular implant/analog with the retention screw in the leaning implant/analog with mean values of EP group closer to M group (Table 6). The reduction of the plaster quantity poured around the analogs during the second pouring in the EP group can explain the approach of its values to that of the M group.

Nevertheless, the vertical misfit showed in the leaning implant/analog when the retention screw was in the perpendicular implant/analog in the EP group differed statistically from the M group (Table 7). This data can be the effect of the variables related to the experimental technique such as the time between the first and the second pouring, the latex tubes manipulation, the alteration of the powder/water ratio and the human intervention. So this technique must be applied with criteria and by a professional who knows its limitations to avoid cast inaccuracy.

Conclusion

- Both pouring techniques produced casts different from the metallic matrix considering the inclination of the leaning implant/analog.
- Perpendicular implants generated more accurate casts than leaning implants independently of the plaster pouring technique.

Resumo

O objetivo deste estudo foi avaliar a influência da inclinação dos implantes na precisão do modelo de trabalho obtido através de duas técnicas distintas de vazamento. Uma matriz metálica contendo dois implantes, posicionados a 90° e a 65° em relação ao rebordo alveolar, foi submetida à técnica de moldagem de transferência direta. No grupo CP (vazamento convencional – n=10) os moldes foram vazados com gesso pedra tipo VI através da técnica convencional. No grupo EP (vazamento experimental – n=10) os análogos foram envolvidos com tubos de látex antes do primeiro vazamento. Após sessenta minutos, os tubos foram removidos e o espaço foi preenchido com nova porção de gesso. A matriz metálica (grupo controle) e as réplicas foram avaliadas com relação à inclinação dos implantes/análogos e à desadaptação vertical entre uma supraestrutura e os implantes/análogos. Os dados foram tabulados e analisados pela análise de variância (ANOVA) e pelo teste de Tukey com nível de significância a 5%. Com relação à inclinação dos análogos, ambos os grupos experimentais exibiram diferença estatística ($p<0.05$) em relação ao grupo controle apenas para os análogos inclinados. Os resultados mostraram diferença significativa ($p<0.05$) entre o grupo controle e os grupos experimentais quando a desadaptação vertical foi observada no implante/análogo perpendicular com o parafuso de retenção localizado no implante/análogo inclinado e entre o grupo controle e o grupo EP na situação oposta. Considerando a inclinação, implantes perpendiculares produzem modelos mais precisos independentemente da técnica de vazamento do gesso.

Unitermos

Prótese odontológica; prótese dentária fixada por implante; precisão do modelo de trabalho; técnica de vazamento do gesso.

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