

Marginal fit of cast titanium copings related to investments and casting techniques

Desajuste cervical de fundições de titânio tipo casquete em função de revestimentos e técnicas

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Abstract

The purpose of this study was to evaluate marginal fit of cast titanium copings according to the following conditions: 1) three investment types (Rematitan Plus, Rematitan Ultra and Ticoat S+L Manfredi), 2) use of a "doll" made up with the three investments and the ring filling with conventional phosphate investment; 3) use of die relief; 4) surface treatment (sandblasting with glassbeads, aluminum oxide, and drilling). Casting was made using appropriate equipment for titanium alloys (F.Ili Manfredi). The results obtained led us to conclude that it is possible to obtain titanium casts with satisfactory marginal fit using adequate techniques; Rematitan investments led to good results, although they may not be used without die relief, especially when the cover technique is employed; Ticoat S+L was the least critical regarding casting techniques, but requires drilling to obtain good fit.

Key words: cast crowns, titanium, cervical fitness, dental materials.

Introduction

Titanium has received great attention by dental researchers and clinicians due to its excellent resistance to corrosion in the oral environment and biocompatibility (THOMAS, 1998; WANG and FENTON, 1996). On the other hand, its high casting temperatures and chemical reactivity at high temperatures led to a more difficult working technique, which requires auxiliary materials and equipments with elevated costs (CRAIG, 1997).

Ida et al., in 1982, presented a commercial casting machine with a tungsten arch as heat source and two argon gas chambers that injected the alloy under pressure. However, still in 1993, Takahashi et al. found better castability with the employment of a centrifuge.

The difficulties inherent to titanium casting resulted in the development of alternatives to obtain prosthetic restorations using this metal. Some authors (ANDERSSON et al., 1989; BOENING, WALTER and REPPEL, 1992; LE-

ONG, et al. 1994) employed electro erosion associated with machining. Samet et al. (1995) employed the CAD/CAM system (Computer aided design/computer aided manufacture). Marginal fit values obtained by these authors varied from 54 to 430 μ m.

The marginal fit problems found by researchers are not solely related to titanium, but also to base metals and noble alloys. According to Fusayama (1959), dental professionals have used other methods to solve this problem, such as digging the wax pattern, machining of the cast restoration using drills, sandblasting, corrosion, etc. Die spacers or relieves (SCHWARTS, 1986) were also suggested and employed by some authors (GHERSEL and MUENCH, 1992).

A comparative study (ORUC and TULUNOGLU, 2000), found better adaptation using base metals than titanium, although the latter was considered as clinically satisfactory. Regarding marginal integrity, in 2002, noble alloys led to more adequate results than tita-

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nium, which was, however, considered as acceptable (STOLL et al., 2002).

Considering the existence of many problems related to fit of cast titanium restorations, it is the purpose of this study to evaluate three commercial investments and some points related to the casting technique: die relief, use of double cover technique and surface treatments (sandblasting with glassbeads, aluminum oxide and drilling).

Material and method

The conditions tested in this study were: 1) three investments (Rematitan Plus and Rematitan Ultra – Rematitan, Germany, and Ticoat S+L – F.lli Manfredi, Italy); 2) two wax pattern inclusion techniques (single filling up with a titanium investment; cover technique with a titanium investment and filling up of the casting ring with a conventional phosphate investment – All Therm CNG, São Paulo/Br); 3) casting with or without relief; 4) four surface treatments (investment removal with glassbeads, Al_2O_3 sandblasting once, Al_2O_3 sandblasting twice and machining with drills).

Therefore, the test was performed with a total of 96 specimens ($n=8$) and consisted of 48 experimental conditions, as each specimen was submitted to four surface treatments. Thus 384 data were submitted to analysis.

Hardi Ti 99.13% titanium alloy (F.lli Manfredi, Italy) was employed for specimen preparation. Die relief was made using the Folident Set system (Dentaurum – Germany).

Wax patterns were obtained with the aid of a metallic matrix (Figure 1). The upper cone of die A (with diameters of 5.65 and 6.92mm, height of 6.98mm, and cone angle of 10.4°) represented a coping preparation. Mould C delimitated a space of 1.2 mm around the cone and with cover D. Spacer B (0.96 mm of thickness) prevented the shoulder from being covered with wax. For specimens obtained following die relief, two pellicles (Folident Set, reference

number 120-130-00 – Dentaurum, Germany) were simultaneously plasticized, placed over die A and immersed in a dish with dense silicone. The pellicle in contact with the die (0.1mm) was responsible for the relief and the other (0.6mm) was submitted to wax build up and became part of the casting pattern.

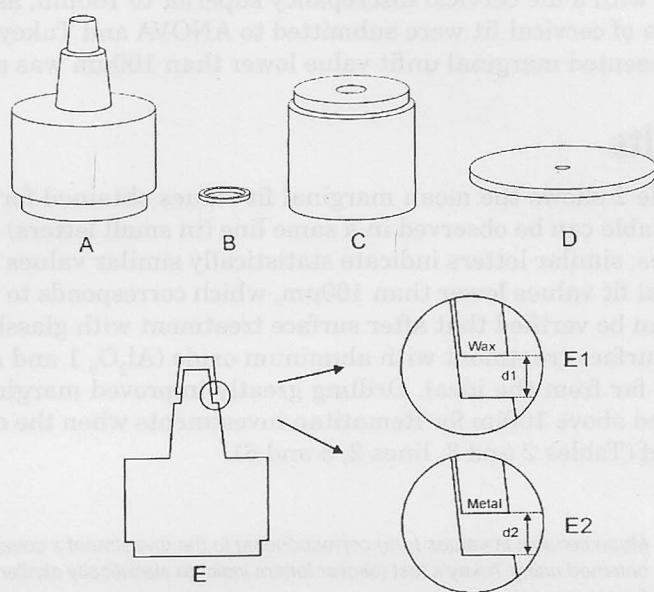


Figure 1 - Schematic representation of die and measuring positions. A) die; B) spacer ring; C) mould; D) cover; E) wax pattern; E1) gap with wax pattern; E2) gap with coping

The sequence to obtain the casting patterns can be visualized in Figure 1. Ring B was positioned and the involved surfaces were lubricated with liquid vaseline. The plasticized wax was then placed on mould C, and die A was seated by loading, using cover D under tap water for 60s. The cover and excess wax were then removed and the wax/pellicle pattern was taken with slight digital pressure under a recipient containing water. After examination and approval, the obtained pattern was stored for 48h at room temperature

To define a measuring position in the die without ring B, a reference was made in the wax pattern (Figure 1 - E1). Four measurements were performed around the die using a caliper (Werth – Germany) under 50x magnification, so that $d1$ mean value was obtained.

After that, four wax patterns were included in each casting ring, joined with a wax bar with 4mm of diameter. At each side, one was made with and the other without relief. Detergent was applied before inclusion. According to the manufacturers' instructions, a metallic ring with ceramic covering was employed for Rematitan Ultra and flexible silicone rings were used for the other two investments. Liquid and powder ratios were strictly followed for each material.

On the double inclusion condition or cover technique, cast ring filling up was made after setting of the first covering with titanium investment. Mechanical handling was made under vacuum conditions. After setting of the second investment (when employed), the thermal cycles were carried out according to Table 1, followed by casting using Easyti induction and centrifuge machine (F.lli Manfredi).

Table 1 - Ring heating rates, temperatures and cycle periods employed in this study

Investment	Heating rate*	Temperatures and cycle periods		
Rematitan Plus	5 °C/min	250 °C/90 min	1000 °C/60 min	430 °C/60 min
Rematitan Ultra	5 °C/min	250 °C/90 min	870 °C/20 min	430 °C/60 min
Ticoat S+L	7 °C/min	260 °C/45 min	1100 °C/45 min	200 °C/60 min

* Cooling rate was always 7 °C/min

Cast copings were initially submitted to sandblasting using glassbeads (50µm). They were subsequently placed over the die under a load of 2kgf, thus determining d2, similarly to d1. The d2-d1 difference supplied the cervical unfit value. After that, internal surfaces were sandblasted with aluminum oxide particles of 120µm (Al_2O_3 1) for 10 to 15s. This step was repeated (Al_2O_3 2) and finally surfaces were drilled using fine grain burs, based on slight contact points left using light silicone impression material. This procedure was performed for copings with a die cervical discrepancy superior to 100µm, as measured in the previous step (Al_2O_3 2).

Data of cervical fit were submitted to ANOVA and Tukey's test for mean contrast. The number of copings that presented marginal unfit value lower than 100µm was also evaluated (%).

Results

Table 2 shows the mean marginal fit values obtained for the 48 experimental conditions. Mean contrasts in this table can be observed in a same line (in small letters) or in a same column (in capital letters). In any of the cases, similar letters indicate statistically similar values ($p>0.05$). Table 3 demonstrates the percentage of marginal fit values lower than 100µm, which corresponds to 0.26% of unfit.

It can be verified that after surface treatment with glassbeads, marginal fit values were still very unfavorable. Surface treatment with aluminum oxide (Al_2O_3 1 and Al_2O_3 2) led to better results, although they were still too far from the ideal. Drilling greatly improved marginal fit in this case. However, marginal unfit still remained above 100µm for Rematitan investments when the cover technique was employed, especially without die relief (Tables 2 and 3, lines 2, 5 and 6).

Table 2 - Mean cervical fit values (µm) corresponding to the investment x cover technique x relief x surface treatment interaction and contrasts obtained using Tukey's test (similar letters indicate statistically similar results - $p>0.05$ - small letters for a same line and capital letters for a same column)

Investment	Cover technique	Relief	Lines	Glassbeads	Surfaces treatments Al_2O_3 1	Surfaces treatments Al_2O_3 2	Drilling
Rematitan Plus	With	With	1	-287 aDE	-155 bIJ	-106 bcOPQR	-72 cT
		Without	2	-594 dA	-406 eG	-363 elM	-229 fs
	Without	With	3	-121 gF	-66 gh JK	-32 hQR	-28 hT
		Without	4	-191 iEF	-66 jJK	-20 jR	-20 jT
Rematitan Ultra	With	With	5	-328 kCD	-292 KH	-269 kMN	-80 fT
		Without	6	-494 mAB	-412 nG	-409 nL	-210 oS
	Without	With	7	-108 pF	-50 pqK	-36 pqPQR	1 qT
		Without	8	-155 rF	-94 rsJK	-65 sPQR	-46 sT
Ticoat S+L Manfredi	With	With	9	-313 tD	-167 µIJ	-129 µOPQ	-44 vT
		Without	10	-428 wBC	-256 xHI	-205 xNO	-15 yT
	Without	With	11	-209 zEF	-163 zIJ	-138 zOP	-35 αT
		Without	12	-203 βEF	-138 βyJK	-94 γµPQR	-18 µT

Table 3 - Frequency (%) of cast restorations in each experimental condition with cervical unfit lower than 100 µm following each surface treatment

Investment	Cover technique	Relief	Lines	Glassbeads	Surfaces treatments Al_2O_3 1	Surfaces treatments Al_2O_3 2	Drilling
Rematitan Plus	With	With	1	0.0	12.5	50.0	100.0
		Without	2	0.0	0.0	0.0	25.0
	Without	With	3	50.0	87.5	87.5	100.0
		Without	4	12.5	75.0	100.0	100.0
Rematitan Ultra	With	With	5	12.5	12.5	12.5	75.0
		Without	6	0.0	12.5	12.5	25.0
	Without	With	7	62.5	75.0	75.0	100.0
		Without	8	25.0	75.0	87.5	100.0
Ticoat S+L Manfredi	With	With	9	0.0	37.50	50.0	100.0
		Without	10	0.0	0.0	25.0	100.0
	Without	With	11	50.0	50.0	50.0	100.0
		Without	12	12.5	62.5	62.5	100.0

Discussion

Tables 2 and 3 demonstrate poor efficacy for the surface treatment using glassbeads. Mean values lower than 100 μm are not found in this situation, a fact that may be confirmed in Table 3, which demonstrates their relatively low frequency. However, these discrepancies would be considered as clinically acceptable in a great number of cases, according to some authors (LEONG et al., 1994, up to 120 μm ; SAMET et al., 1995, from 111 to 270 μm), although they also wished a value lower than 100 μm . Schwarts (1986) referred to an interval between 10 to 160 μm . The low efficacy obtained for surface treatment with glassbeads is in accordance with Mori et al. (1994), who consider this technique good only to clean the restoration surfaces.

Rematitan investments presented favorable results at a reasonable frequency when cover technique was not performed after the first sandblasting with aluminum oxide (Al_2O_3 1), even when die relief was not made. The second sandblasting with aluminum oxide (Al_2O_3 2) did not really improve the situation. More satisfactory results were, however, obtained after drilling, especially for Ticoat S+L. After the second aluminum oxide application, results were still too unsatisfactory, but they were able to reach 100% of satisfactory cases with surface drilling. The 100% index was not achieved for Rematitan investments when cover technique was used, although with previous surface treatments they presented relatively more satisfactory results. The cause for these results may be a greater difficulty in machining blocks obtained using Rematitan investments, a fact that may be due to the existence of a thinner layer (MIYAKAWA et al., 1989) than in blocks prepared with Ticoat S+L investment. This layer would be more easily machined than practically pure metal.

The marginal unfit observed for titanium is also found with con-

ventional alloys. Mean marginal fit values of up to 600 μm are observed when noble alloys (MUENCH and MALUF, 1973) and alloys with low content of gold (MUENCH et al., 1984) are employed. Values up to 600 μm (LOVADINO, 1991) or around 300 μm (BALLESTER, 1999; GUARALDI et al., 1998) can be found in the literature for nickel-chromium alloys.

In a first instance, cover technique with investments for titanium and filling up of the cast ring with a less expensive material may be used for casting procedures, as long as adequate relieves are made, maybe even with larger thicknesses than those used in the present study. This technique was already used by several authors (GHERSEL and MUENCH, 1992; GUARALDI et al., 1998; SCHWARTS, 1986), and is also recommended by Shillingburg Júnior et al. (1998).

Irregularities observed in the cast surfaces (BALLESTER, 1999; MUENCH et al., 1984) and their possible interference in adaptation may be removed by machining with drills, thus enhancing marginal fit (BALLESTER, 1999; FUSAYAMA, 1959; GUARALDI et al., 1998; SCHWARTZ, 1986; SHILLINGBURG JÚNIOR et al., 1998).

It was verified that the three investment materials may be employed, although they present advantages and disadvantages. Ticoat S+L was very good when employed with cover technique, whereas Rematitan materials made adjustments with drilling more difficult, although they achieved reasonable results before surface treatment. The latter should therefore be used with relieves or thicker die spacers.

As a final consideration, it may be observed that it is possible to prepare titanium restorations with similar fit to those obtained by other authors (BALLESTER, 1999; FUSAYAMA, 1959; GUARALDI et al., 1998; LOVADINO, 1991; MUENCH and MALUF, 1984) with conventional alloys, despite the difficulties that may be found during casting procedures.

Conclusions

Results obtained led us to conclude that:

1. Rematitan Plus and Rematitan Ultra led to satisfactory results at a great frequency, either with or without die relief, when the cover technique was not employed, and after surface treatment with aluminum oxide. However, when the cover technique was used, die relief became necessary. Drilling not always led to satisfactory results;
2. After surface treatment with aluminum oxide, Ticoat S+L investment led to still unsatisfactory results, although all copings achieved good marginal fit after drilling;
3. With the purpose of reducing casting costs, the cover technique may be employed with the three tested investments, but it requires special care regarding use of die relief, especially for Rematitan materials.

Resumo

O objetivo deste estudo foi avaliar o desajuste marginal de casquetes fundidos de titânio preparados de acordo com as seguintes condições: 1) três diferentes revestimentos (Rematitan Plus, Rematitan Ultra e Ticoat S+L Manfredi); 2) emprego de "boneca" feita com os três revestimentos e preenchimento do anel com revestimento fosfatado convencional; 3) uso de alívio no troquel; 4) tratamentos superficiais (com partículas de vidro, óxido de alumínio e usinagem com broca). A fundição foi feita com equipamento próprio para titânio (F.lli Manfredi). Os resultados permitiram concluir que com técnicas adequadas foi possível conseguir fundições de titânio com adaptação cervical satisfatória; os revestimentos Rematitan conduzem a bons resultados, mas não podem ser empregados sem alívio, principalmente quando empregada a "boneca"; o revestimento Tico-

at S+L é o menos crítico em relação às técnicas de fundição, mas exige usinagem com broca.

Palavras-chave: coroas dentárias, fundição, titânio, ajuste cervical, materiais dentários.

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