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The Effects of Dry and Wet Casting Ring Liners and the Ringless Casting Technique on Marginal Adaptation of Casting Crown

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Abstract: Numerous conflicting studies have been published regarding the importance of marginal adaptation of casting restorations on prepared teeth and moreover, the influence of investing methods. The present study examined the effects of four common investing methods (one-layer dry casting ring liner, one-layer and two-layer wet casting ring liner and ringless casting technique) on the marginal gap of castings on the die. Ten wax patterns were invested utilizing the aforementioned methods by phosphate-bonded investment. The marginal gap of each casting on a die was measured blind under a stereoscopic microscope. One way Analysis of Variance (ANOVA) with a Tukey HSD multiple comparisons Post-hoc test were statistically significant at $p<0.05$. The mean±SD for the castings marginal gap in the four investing techniques was 86±33 μm (one-layer dry casting ring liner), 42±32 μm (one-layer wet casting ring liner), 50±28 μm (two-layer wet casting ring liner) and 163±77 μm (ringless casting). The differences were statistically significant ($p<0.05$). The one and two-layer wet casting ring liner methods are the most reliable and appropriate techniques for the production of dental castings with the least marginal gap.

Key words: Dental casting, ring liner, marginal adaptation, wet liner, investing techniques, post-hoc, Iran

INTRODUCTION

Some researchers demonstrated that the raising the number or thickness of liners results in an increase in setting expansion (Mahler and Ady, 1963; Davis *et al*., 1992) or total expansion (Anusavice and Phillips, 2003; Rosenstiel *et al*., 2006) and further that could cause larger casting (Gil *et al*., 1982; Takahashi *et al*., 1994). In contrast, Wang and Chao (2005) have reported no statistically significant difference on the casting accuracy using various thicknesses of liner. In support, Shell (1969) has stated that use of more wet liners has no significant effect on total expansion.

Mahler and Ady (1963) have shown that a wet one liner, compared with a dry one liner produces greater setting expansion but Shell (1968) has reported no difference in total expansion in the aforementioned liners. Keyf and Erman (2000) have demonstrated that marginal adaptation of a casting produced by a dry one liner does not show a statistically significant difference from a casting made by a wet one line but Earnshaw (1988) has stated the total expansion along a dry one liner is greater than in a wet one liner, a difference which is statistically significant. However, he predicted that we can fabricate clinically accurate castings by use of wet cellulose liners but Gil *et al*. (1982) reported the use of dry ceramic ring liners contrary to pre-wetted ceramic ring liners produced very inconsistent castings which were generally unacceptable. However, Davis (1996) has demonstrated that a dry two liner, comparing with a wet two liner has a statistically significant effect on fabricating castings of more accurate adaptation.

As a result whilst Rosenstiel *et al.* (2006) have recommended use of dry casting ring liner according to the aforementioned studies (Earnshaw, 1988; Davis, 1996). Shilingburg *et al.* (1997) have preferred wet casting ring liners to provide similar results. With regard to the diversity of ringless systems, Lombardas *et al.* (2000) have suggested such methods for the improvement of the casting adaptation on die and the reduction of casting distortion due to uniform vertical and horizontal setting expansion in investment mould. Arikawa *et al.* (1981) have reported that the ringless casting techniques result in the best adaptation on die and the least distortion. Moreover, Junner and Stevens (1986) have reported that use of flexible casting rings produce uniform and consistent longitudinal and transverse setting expansion in investment. Lombardas *et al.* (2000) have documented that the ringless casting technique has a statistically significant role in fabricating castings of less marginal

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gap, compared with the wet one-layer casting ring liner. Still the ineffectiveness of such techniques as ringless casting and dry one-layer casting ring liner on cast ability percent has been reported (Dern *et al*., 1985).

MATERIALS AND METHODS

Fabrication of full crown wax patterns: For fabricating similar full crown wax patterns a stainless steel die assembly was utilised (Fig. 1). A plastic spacer disk (Adapta, Bego Gmbh and Co., Bremen, Germany), 0.1 mm thick was used. The wax patterns were fabricated with a thickness of 1 mm in occlusal and axial walls. The wax pattern was removed from the die and stored for 24 h at room temperature in a plastic container to release its internal strain and stress (Schilling *et al*., 1999; Fusayama, 1959; Suffert and Mahler, 1995).

After 24 h, the wax patterns were placed in turn on the metal die for margin refinement. A margin of 1 mm width was adapted to the die finishing line. A stereoscopic microscope (Nikon, SMZ-800, Nikon Inc., Melville, NY) was used (×32 magnification) to examine the vertical margin adaptation at four predetermined reference points (Fig. 2). To prevent distortion in the wax pattern, prior to its removal from the die (Mackert Jr., 1988), a wax sprue (round in cross-section with a diameter of 10-gauge and a length of 6 mm) was attached to the edge of the occlusal surface at an angle of 45° to the wax pattern axis and at the buccal reference point. In order to minimize distortion in the wax pattern, investing was done immediately after margin adaptation (<30 min).

Wax pattern investing

Dry one-layer casting ring liner group: In the dry one-layer casting ring liner group, a one-layer liner of cellulose (Whip-Mix Corp., Louisville, KY) with the height of 35 mm was placed into a ring of cast iron with an internal diameter of 30 mm and height of 41 mm thus, they were positioned 3 mm below the two edges of the ring.

Wet one-layer casting ring liner group: In the wet one-layer casting ring liner group after placing the liner inside the casting ring according to the manufacturer recommendations, the lined ring was immersed in distilled water for 5 min in order to wet the liner. The lined ring was then removed from the water and shaken until dripping of excess water ceased (Davis, 1996; Suffert and Mahler, 1995).

Wet two-layer casting ring liner group: In the wet two-layer casting ring liner group, prior to wetting, two layers of liner were placed inside the ring.

Fig. 1: Stainless steel die assembly

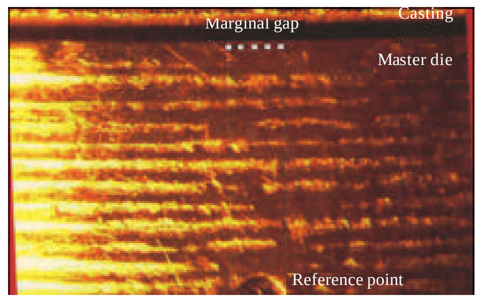

Fig. 2: Micrograph of marginal gap

Ringless casting group: In the ringless casting group, a polyester ring of cylindrical shape with an internal diameter of 30 mm and height of 41 mm was used. The wax pattern surfaces were sprayed with debubblizer surfactant (Smootex, Whip-mix Corp., Louisville, KY) then allowed to dry in air. According to the manufacturer's recommendations phosphate-bonded investment (Accufit, Prevest Inc., Cleveland, OH) together with liquavest (Prevest Inc., Cleveland, OH) was poured in the casting ring.

After an hour at room temperature it became bench set as advised by the manufacture. In the ringless casting group, 10 min after investment completion (instantly following the initial set of investment) (Junner and Stevens, 1986; Dern *et al*., 1985) when the investment warmed as a result of exothermic reaction of setting (Dern *et al*., 1985), the polyester ring was parted from the investment mould to allow the investment to expand freely across all directions. Investment moulds were placed in an electric burnout furnace (Jelrus Technical Product Corp., New Hyde Park, NY) equipped with a digital thermal controller calibrated with a Ni Cr-Ni thermocouple according to the manufacturer's recommendations.

Wax pattern casting: An expert laboratory technician cast one Ni-Cr-Be base metal alloy bar (Verabond, Aalba Dent., Cordelia, CA) with the aid of a one-orifice gas-oxygen torch in centrifugal casting machine (Kerr Mfg Co., Romulus, MI). The moulds were allowed to cool at room temperature. Nodules in the internal surfaces of the castings were removed under a stereoscopic microscope at ×32 magnification.

Recording measurements: An expert clinician (a blind operator) measured marginal gap non-consecutively fifteen times at each four reference point under a stereoscopic microscope (Nikon SMZ-800, Nikon Inc., Melville, NY) (Fig. 2).

Statistical analysis: All data were statistically analysed using SPSS 10. A one-way univariate analysis of variance (univariate ANOVA) was used at $p<0.05$. Detection of a statistically significant difference between the marginal gaps among the techniques and the reference points warranted a Tukey HSD multiple comparisons Post-hoc test.

RESULTS AND DISCUSSION

The averages of castings marginal gap at each of the four reference points in the four investing techniques are shown in Table 1. Statistically significant differences were evident between the investing techniques ($p<0.001$). The dry one-layer casting ring liner method produced significantly smaller marginal gaps compared to the ringless casting method ($p<0.001$) and bigger marginal gaps compared to the wet one-layer casting ring liner method and the wet two-layer casting ring liner method ($p = 0.001$ and $p = 0.003$, respectively). With regard to castings marginal gap there was no significant difference ($p = 0.977$) between the wet one-layer casting ring liner and the wet two-layer casting ring liner methods.

There were no significant differences between the reference points in various investing techniques ($p = 0.483$). Moreover, the investing techniques did not introduce any significant interactions among the results at reference points ($p = 0.984$). The present study demonstrates that the wet one-layer and wet two-layer liner techniques have statistically significant ($p<0.001$) reduced marginal gaps on the die compared with the ringless casting and dry one-layer liner techniques. Thus conceivably, the technique of wet casting ring liner owing to an increase in compensatory expansion of investment, results in proved adaptation of castings on the die. Although, these results are supported by Mahler and Ady (1963) and Earnshaw (1988) reported the other. Additionally were emphasized that the influence of casting ring liners on casting accuracy can be determined only by direct measurement of the fit of the castings made under practical conditions (Earnshaw, 1988; Morey and Earnshow, 1992). Keyf and Erman (2000) reported no statistically significant differences between castings margin adaptation from the wet and dry one-layer liner techniques. Davis (1996) has reported that the dry two-layer liner technique has a statistically significant priority over the wet two-layer liner technique in terms of castings with more accurate adaptation. However in the aforementioned study (Davis, 1996) the wax pattern margin was not examined and refined under a microscope prior to investing.

Table 1: Averages of castings marginal gap at the reference points in the four testing groups in μm (mean±SD)

	Investing techniques (casting ring liner)			
Reference points	Dry one-layer	Wet one-layer	Wet two-layer	Ringless casting
Buccal	82±33	49±30	48±24	152±64
Mesial	90±35	60±29	63±24	172±78
Lingual	89±34	33±35	48±35	171±95
Distal	84±34	43±30	42±26	158±80
Average of the points	86±33	46±32	50±28	163±77

Both techniques of wet casting ring liner are suitable for producing castings of best adaptation. Whilst several studies advocate this result (Wang and Chao, 2005; Shell, 1969). The outstanding increase in castings marginal gap in the ringless casting technique, compared to other three techniques can originate from the compensatory decrease of investment expansion in the ringless technique or the non-isotopic compensatory expansion within it. It is possible that the application of ringless systems which expand in response to the heat caused by investment setting reaction such as the soft polyethylene (Engelman *et al.*, 1985, 1989) or polyvinyl (Harms and Harms, 2003) casting ring will produce castings with better adaptation.

In the ringless casting technique to improve casting adaptation, it is recommended that die spacer be used in greater thickness on axial and occlusal walls. Moreover, negligible setting expansion and unlimited thermal expansion are required to compensate for alloy shrinkage. (Finger and Kota, 1982; Finger and Jorgensen, 1980; Jorgensen and Finger, 1979). At the study by Lombardas *et al.* (2000) however, investment types and casting rings diameters were different among test groups. Furthermore, examination and elimination of nodules on the castings internal surfaces was overlooked. In the present study every casting showed uniform adaptation on various points of the casting margin on the die. The ringless casting technique is easier and more economical. However in order to modify the ringless casting technique to produce castings of appropriate and acceptable adaptation on a die, more research is required.

Clinical significance: In terms of marginal adaptation, wet casting ring liners produce clinically acceptable castings.

CONCLUSION

The wet one and two-layer liner techniques demonstrated a statistically significant decrease ($p<0.001$) in the marginal gap of castings on die. Moreover, they produced an clinical acceptable marginal gap compared to both the dry one-layer liner and the ringless techniques and were therefore, clinically better techniques for casting production. All castings in all four techniques demonstrated uniform adaptation at different points of the margin. Therefore, the investing and sprue placement protocol developed in the present study is suitable for the production of uniform castings.

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