Analysis of the marginal gap of complete crowns made by using wet and dry ceramic ring liners – an *in vitro* study

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The ultimate assessment of cast restoration lies in the accuracy of fit of the casting. Ring liners, through their compressibility, act as a buffer of pliable material between the expanding investment material and the rigid metallic ring. Asbestos, the traditionally used buffer, has now been found to be a potential carcinogen, leading to its withdrawal from use and subsequent introduction of its alternatives i.e. cellulose and ceramic ring liners. This *in vitro* study was undertaken to evaluate the marginal gap of complete crowns made by using wet and dry ceramic ring liners using a scanning electron microscope. Two groups of thirty castings each were prepared with dry and wet ceramic ring liners respectively and assessed for marginal fit. Results showed that crowns made by using dry ceramic ring liners had significantly less marginal gap as compared to the crowns made by using wet ceramic ring liners.

Key words: Ring Liners; Crowns; marginal fit

INTRODUCTION

The accuracy of fit of casting is essential for longivity and clinical success of the cast restoration in the oral cavity. The accuracy of casting is subject to material volumetric changes occurring due to shrinkage of wax and alloys. This shrinkage can be compensated by setting expansion, hygroscopic expansion or thermal expansion of the investment.[1] As this expansion is restricted because of rigid metallic ring, hence the need for a ring liner which acts as a buffer. For many years asbestos was being used as the ring liner of choice [2]. Reports of asbestos fibres being carcinogenic has lead to alternative ring liners like cellulose and ceramics being introduced.[3,4]

Ceramic ring lining material is made from fibres of an alumino-silicate glass derived from Kaolin. The major components are alumina (47-65wt%) and silica (38-50wt %), so the material is highly heat resistant, being suitable for use at temperature of 1300^{0}C. This property of ceramic ring liners has made it more acceptable for use with base metal alloys like nickel-chromium which have high melting points (1260-1460^{0}C). The casting ring liners are used either dry or are prewetted before being invested in the metallic casting ring. The ceramic ring lining material does not absorb water like a cellulose liner; however, its network of fibres can retain water on the surface.[5] This study was conducted to compare the accuracy of fit of single unit nickel-chromium complete crowns made by using dry and pre-wetted ceramic ring liners.

MATERIALS AND METHODS

Study sample

The study was conducted *in vitro* on 60 stone dies duplicated from a brass master die simulating a prepared pre-molar tooth. A counter die with dimensions 1mm larger than the master die was made in order to make wax patterns of uniform dimensions. [Figure 1]

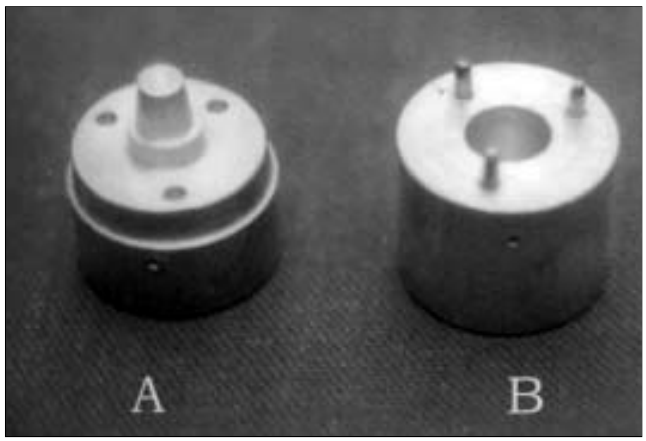

Figure 1: (A) Master die simulating the prepared tooth. (B) Counter die

Preparation of castings

The brass master die was duplicated by using a custom tray of auto polymerising acrylic resin and polyvinyl siloxane impression material. The resultant impression was poured with die stone to obtain a stone die. Sixty stone dies were prepared in this manner and were divided into groups of thirty each as follows:

group-I – castings made by using dry ceramic ring liner

group-II – castings made by using wet ceramic ring liner

Wax patterns were made on stone dies. The brass counter die was closed over the stone die to obtain a wax pattern of uniform thickness. The margins were refined using wax carving instruments. A wax sprue was attached to the occlusal surface and the wax pattern was invested immediately in a phospate bonded investment. The ceramic ring liner (S.U. Denta Vlies-Germany) was kept 3mm short at either of the casting ring with no overlap.

In case of wet ceramic ring liner, the lined ring was immersed in water for 5 minutes and then allowed to drain until dripping of excess water ceased. The water: powder ratio of phosphate bonded investment material was kept at 0.23: 1. The invested ring was allowed to bench set for 60 minutes and the casting ring was placed in a muffle furnace at room temperature. The temperature was raised at a rate of 80C/ min to 2700C and heat soaked for 30 minutes. Thereafter, the temperature was raised to 5800C and heat soaked for 30 minutes and finally the ring was heated to 8500C with a holding time of 40 minutes. The ring was thereafter bench cooled to room temperature.

The casting procedure was performed by using an induction casting machine. Nickel chromium alloy was used to fabricate the castings. The castings were recovered, sprues were cut and castings were refined and polished.

Measurement of marginal gap

The castings were seated on the stone die with finger pressure. Marginal gap was measured using a scanning electron microscope (JEOL JSM 6100) at a resolution of 150X.

[Figure 2 & 3] The margin of each casting was scanned at 4 randomly selected points. The pictomicrograph obtained from each of the 4 points were then analysed and 13 measurements at equally spaced intervals were measured from each pictomicrograph resulting in 52 measurements of the marginal gap per casting [Figure-4]. The mean of the 13 measurements for each of the 4 points on each casting was calculated and tabulated for analysis.

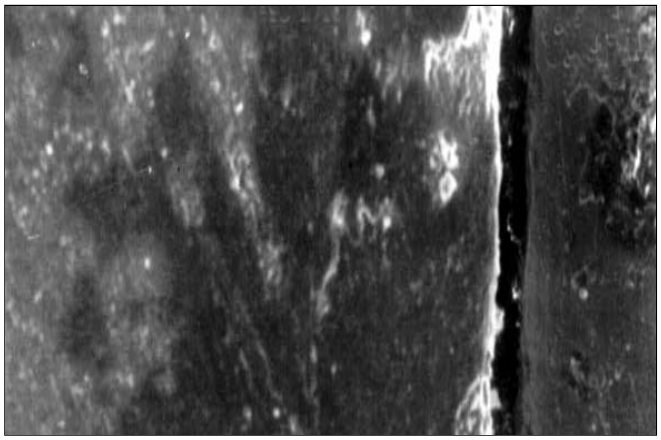

Figure 2: Pictomicrograph of marginal gap of casting made by using dry ceramic ring liner

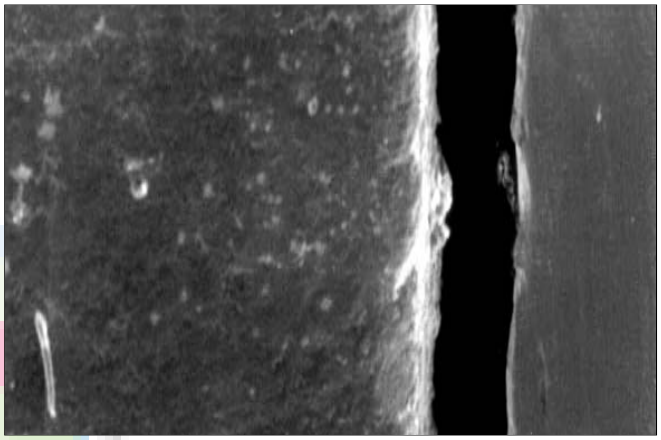

Figure 3: Pictomicrograph of marginal gap of casting made by using wet ceramic ring liner

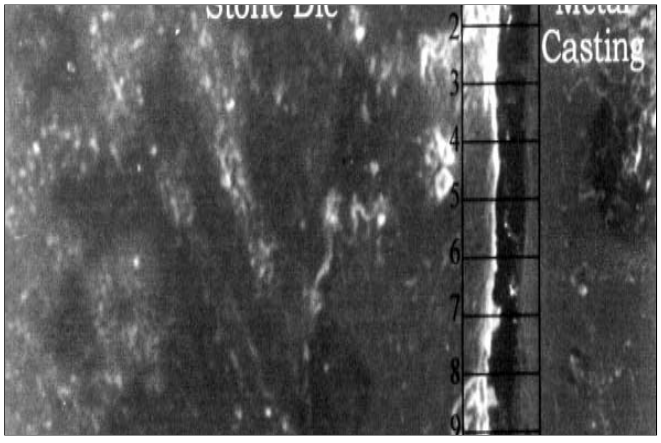

Figure 4: Pictomicrograph of marginal gap with superimposed grid showing 13 equally spaced reading sites

RESULTS AND OBSERVATIONS

The results of measurements by scanning electron microscope of the 60 sample castings is depicted in

[Table 1]. Group I castings made by using dry ceramic ring liner showed a mean marginal gap of 54.5µm while group II castings made by using wet ceramic ring liner presented a mean marginal gap of 153.0µm.

The values were subjected to Student's '*t*' test to assess the statistical significance if any between the difference in the mean marginal gaps observed in the two groups of castings. The results revealed that the values were statistically highly significant ($P<0.01$) when comparison was made between the two groups under study. The computed value of the *t*-statistic was 22.806 as compared to the critical values of 1.96 and 2.58 at 5% and 1% level of significance respectively.

DISCUSSION

Souder was the first in suggesting the use of a ring liner which would act as a cushion to permit the investment to undergo full thermal expansion.[2] The knowledge of potential carcinogenic effect of asbestos, which was the most commonly used ring liner, lead to assessment of various alternatives as ring liners. Cellulose and ceramics based ring liners were widely studied as alternatives to asbestos and accepted as effective ring liners. Yli Urpo et al reported that ceramic ring liners produced good and reproducible accuracy comparable or better than the conventional asbestos material.[6] Nasu and Noguchi reported that ceramic ring liners provided better cushion ability than asbestos for the expansion of investment.[7] Since asbestos readily absorbs water from the investment it had to be wetted before use. Scheu reported an increase in setting expansion of the investment when the wet ring liner was used.[8] Takahashi found that the use of ceramic ring liners eliminated this hygroscopic setting expansion effect since ceramic ring liners absorb less quantity of water as compared to asbestos.[9]

According to Morey EF and Earnshaw R ceramic ring lining material based on alumino-silicate fibres, absorb very small amounts of water at atmospheric pressure, hence these are normally used dry.[10] However, the network of fibres of ceramic ring liners can retain water on the surface.[5] Thus in the present study comparison was made in the accuracy of cast crowns made by using dry and wet ceramic ring liners, by measuring the marginal gap of the castings made with the help of a scanning electron microscope. It has been considered that a marginal gap upto 71 µm is acceptable as accuracy of marginal fit as advocated by Anusavice.[11] The results of the present study suggest that the use of dry ceramic ring liner is more appropriate (mean of 54.5 µm achieved in the study) than the use of wet ceramic ring liners (mean of 153µm achieved in the study)

Table 1: Details of statistical data regarding measurements of marginal gap of castings made by dry and wet ceramic ring liners

	Group –I dry ceramic liner	Group –II wet ceramic liner
No of castings	30	30
No of measurements(mean of 13 measurements was taken for each of 4 points on each casting)	120 (30 x 4)	120 (30 x 4)
Mean marginal gap (in µm)	54.5	153.0
Range (in µm)	3.8 – 130.7	43.5 – 256.9
Standard deviation (SD)	26.849	38.707
Standard error of mean (SE)	2.461	3.548

t-(difference of means of 2 groups)= 22.806; df=238; $P< 0.01$

CONCLUSION

The results of the present study have demonstrated that the castings made with dry ceramic ring liner exhibited a lower mean marginal gap (54.5µm) as compared to those made with wet ceramic ring liner (153.0µm). The difference was statistically highly significant, $P< 0.01$. It is therefore concluded that in order to obtain castings with a lesser marginal gap, it is advisable to use a dry ceramic ring liner rather than a wet ceramic ring liner.

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