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ORIGINAL ARTICLE

Influence of Time of Placement of Investments for Burnout and the Type of Rings Being Used on the Casting Accuracy

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Abstract The sole objective of casting procedure is to provide a metallic duplication of missing tooth structure, with as great accuracy as possible. The ability to produce well fitting castings require strict adherence to certain fundamentals. A study was undertaken to comparatively evaluate the effect on casting accuracy by subjecting the invested wax patterns to burnout after different time intervals. The effect on casting accuracy using metal ring into a pre heated burnout furnace and using split ring was also carried. The readings obtained were tabulated and subjected to statistical analysis.

Keywords Casting · Investment · Burnout

Introduction

Dimensional accuracy is essential for successful dental casting which is not always secured irrespective of claims made. The sole objective of casting procedure is to provide a metallic duplication of missing tooth structure, with as great accuracy as possible. The ability to produce well fitting castings require strict adherence to certain fundamentals.

Various factors influence the success of casting which include the sprue design, nature of investment material and alloy type [1, 2]. There are few more that would influence the accuracy of castings. To name, some are; the time and placement of the investment in the burnout furnace, temperature schedule of the burn out and the use of different type of rings.

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Purpose

The purpose of this study was to investigate the influence of time of placement of investments for burnout and the type of rings being used; on the casting accuracy with the following objectives:

1. Subjecting the investment ring to burnout at various time intervals from the time of mixing of investment and to correlate their effects on casting accuracy.
2. Burnout of the investment into a pre heated furnace and to co relate its effects with the routine burn out schedule.
3. Use of plastic split ring and to co relate its effect with a normal metal ring with a liner.

Materials and Methods

Fabrication of Gun Metal Die and a Sleeve

A uniform cylinder shaped gun metal die and a sleeve (Fig. 1) were machined meticulously and precisely in the Tools Room of Central Institute of Plastic Engineering and Technology, Chennai, India. The metal die and the sleeve were used to obtain standard size wax patterns. The gun metal was chosen because it would not yield to the vigor's of fabrication procedure.

Fig. 1 Gum metal die and Sleeve

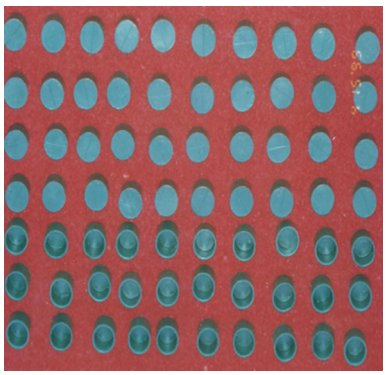

Fig. 2 Wax patterns

Fabrication of Wax Patterns

A fine coating of liquid paraffin was applied on the die and the inside of sleeve with the help of hair brush. Inlay wax was then melted on specially prepared stainless steel spoon using the Bunsen burner and poured into the space between the die and the sleeve. After the initial setting of the wax slight pressure was applied on the wax to make it adapt properly to the die. A warm flat glass plate was then pressed several times over the excess wax, to level it to the top of sleeve. The wax was then allowed to set properly. The pattern was removed from the die carefully and checked for accuracy. Forty such wax patterns were made and were divided into five groups namely I–V; each group comprised of eight wax patterns (Fig. 2).

Two scribe lines were drawn on the wax patterns, one along the centre of the top of the wax pattern to be designated as occlusal surface and another along the long axis of the wax pattern to be designated as occlusogingival length for the purpose of this study; using a PKT carver and a measuring scale.

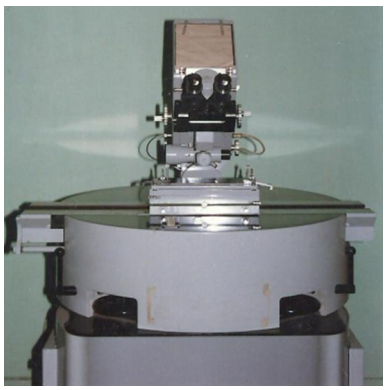

Fig. 3 Measuring microscope (Resolution 1 μm)

These patterns were numbered along the occlusogingival length from 1 to 40. The patterns were enclosed in plastic molds created for this purpose to prevent any distortion during scribing of lines and numbering.

The wax patterns were then measured along the scribed line using a measuring microscope at IIT Chennai (Fig. 3).

Spruing of Wax Patterns

4 mm long preformed wax sprues of 2.5 mm diameter were attached to the Group I wax patterns (1–8) on one side of scribed line on the occlusal surface of pattern. A circular ring of wax was made from the preformed wax sprue of 65 mm long and 4 mm diameter. Seven sprued wax patterns were then attached to sprue former with three sprues of 25 mm long and 4 mm diameter suspending from the circular ring at equal distances from each other. 8th sprued wax pattern was attached to the sprue former through the centre of the circular wax ring with the help of vertical sprue of 20 mm long and 4 mm diameter; in such a way that it was equidistant from all other seven wax patterns (Fig. 4).

Investing of Wax Patterns

All eight wax patterns were treated with a de bubblizer to reduce the surface tension so that investment comes into close contact with the wax pattern. The patterns were then washed with water. The casting ring with a cellulose liner which is kept 3.25 mm short from the ends of the metal ring was placed on the crucible former and secured with sticky wax. 240 g of phosphate bonded investment powder was mixed with 55.5 ml of liquid I a clean flexible rubber bowl with a stiff blade metal spatula. A thin coat of the mix was applied on the individual pattern and the ring was placed on vibrator. The remaining investment was poured slowly without entrapping air bubbles till the investment covered whole of casting ring.

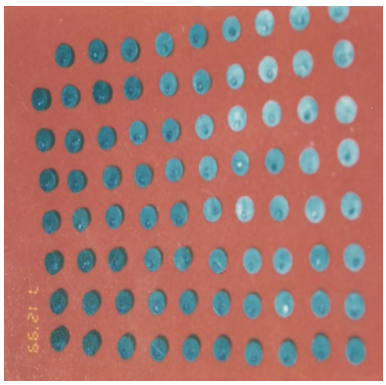

Fig. 4 Sprued wax patterns

Fig. 5 Wax patterns before investing attached to sprue former

Fig. 6 Metal frameworks showing various groups of castings

Burnout Procedure

After initial setting the metal casting ring was separated from the crucible former and balanced on the centrifugal arm of the induction casting machine by adjusting the counterweight. This counter weight scale has markings for mold sizes 1–9 and weights of 200–600 g. After 20 min from the time of mixing of investment, the metal casting ring was placed in the burnout furnace. A casting crucible was also placed in the furnace for pre heating. A two stage burnout procedure was opted. This burnout schedule was from room temperature to 250 °C for 30 min and then increasing the temperature to 900 °C. Once the maximum temperature was reached, the ring was heat soaked for half an hour. 40 g of metal was put into casting crucible for 5 min before casting for preheating the metal.

Casting Procedure

After a thorough burnout the ring was transformed to a previously balanced inducting casting machine (Fig. 5). The preheated quartz crucible along with pre heated metal ingots was transferred to the casting machine. Metal casting ring was allowed to cool down to the room temperature gradually. The framework was recovered by careful divesting procedure (Fig. 6). The sprues were detached using cut off disks.

The remaining wax patterns were also scribed along the centre of the occlusal surface and along the occlusogingival length and numbered in the same manner as was done for Group I wax patterns. Group II wax patterns were put for the furnace after 1 h, Group III after 2 h, Group IV after 24 h and Group V after 3 days from the time of investment and the casting procedure was carried out in the same manner as mentioned previously.

The frameworks were retrieved and sprues were cut from the castings. The castings were measured across the scribed lines. The measurements were tabulated (Tables 1, 2).

A continuation of this study was thought of and two more groups of wax patterns were made; Group VI (41–48) and Group VII (49–56). These patterns were scribed and measured as was done earlier.

The Group VI specimens were invested using metal casting ring and a liner and after 1 h from the time of mixing of investment, the metal ring was transferred into the preheated burnout furnace with a temperature of 900 °C; heat soaked for half an hour and casting carried out. The framework was retrieved and sprues were cut from the casting. The scribed lines were measured and tabulated. (Tables 1, 2).

The Group VII specimens were invested using a split plastic ring without using any liner. After the initial set the split plastic ring was removed and the investment was allowed to expand freely. The investment was put for burnout after 1 h from the time of mixing of investment. Burnout and casting was carried out in the same manner as was done for Group I investment ring. The castings were measured along the scribed lines and the results were tabulated. (Tables 1, 2).

Table 1 Mean and SD of radial measurements

Group	Wax pattern (mm)	Casting (mm)	Discrepancy (mm)	Percentage discrepancy (%)
I	10.464 ± 0.081	10.446 ± 0.067	−0.025 ± 0.014	−2.237 ± 0.130
II	10.449 ± 0.047	10.446 ± 0.044	0.017 ± 0.004	0.158 ± 0.043
III	10.445 ± 0.036	10.458 ± 0.034	0.013 ± 0.009	0.126 ± 0.087
IV	10.479 ± 0.020	10.470 ± 0.020	−0.009 ± 0.005	−0.008 ± 0.050
V	10.461 ± 0.076	10.437 ± 0.080	−0.016 ± 0.015	−0.157 ± 0.141
VI	10.523 ± 0.073	10.505 ± 0.006	−0.040 ± 0.013	−0.374 ± 0.117
VII	10.450 ± 0.063	10.496 ± 0.070	0.038 ± 0.026	0.368 ± 0.250

Table 2 Mean and SD of axial measurements

Group	Wax pattern (mm)	Casting (mm)	Discrepancy (mm)	Percentage discrepancy (%)
I	7.537 ± 0.049	7.504 ± 0.051	0.034 ± 0.021	−0.444 ± 0.282
II	7.560 ± 0.058	7.587 ± 0.069	0.027 ± 0.023	0.360 ± 0.309
III	7.513 ± 0.062	7.535 ± 0.061	0.022 ± 0.016	0.293 ± 0.215
IV	7.533 ± 0.072	7.520 ± 0.073	−0.014 ± 0.007	−0.183 ± 0.096
V	7.536 ± 0.067	7.513 ± 0.068	−0.023 ± 0.019	−0.298 ± 0.258
VI	7.479 ± 0.123	7.434 ± 0.127	−0.045 ± 0.019	−0.067 ± 0.257
VII	7.559 ± 0.054	7.619 ± 0.012	0.060 ± 0.050	0.795 ± 0.655

Results

1. Group I (burnout carried after 20 min): Unsatisfactory casting; undersized 0.237 % radially and 0.444 % axially.
2. Group II (burnout carried after 1 h): Satisfactory casting; oversized 0.158 % radially and 0.360 % axially.
3. Group III (burnout carried after 2 h): Satisfactory casting; oversized 0.126 % radially and 0.293 % axially.
4. Group IV (burnout carried after 24 h): Unsatisfactory casting; undersized 0.088 % radially and 0.183 % axially.
5. Group V (burnout carried after 3 days): Unsatisfactory casting; undersized 0.157 % radially and 0.298 % axially.
6. Group VI: Unsatisfactory casting; maximum shrinkage undersized 0.374 % radially and 0.607 % axially.
7. Group VII: Unsatisfactory casting; oversized 0.368 % radially and 0.795 % axially.

The results are graphically depicted in Charts 1 and 2

Discussion

The production of accurate dental castings by the "lost wax" process involves casting molten metal alloy into a refractory mold which is sufficiently and precisely oversized to accommodate the shrinkage of the alloy during cooling [3]. The most commonly used technique to provide investment expansion is to line the walls of the ring with a liner. Fusayama [1, 2] stated that the required thickness of lining is 2 mm for an investment.

The placement of the investment for burnout from the time of mixing the investment plays an important role. Because the entire process involving phosphate investments takes a long time, the demand for time saving changes is universal. The tall claims made by manufacturers about immediate placement after mixing, to save time is questionable. To save more time some authors recommend usage of plastic rings instead of metal ring with a liner. According to them plastic ring should be tapered or splited to facilitate easy removal of the investment after its initial set. But these claims have not been well documented till date. Therefore this study was carried out, as from the available review of literature no such comparative study was undertaken.

When the burnout procedure was carried out after 20 min, the casting obtained was undersized. This is possibly due to lack of adequate time for setting expansion. This finding is in agreement with Schnell et al. [4] according to whom, the phosphate investments do not gain strength as rapidly as the short working time might indicate. The 30 min setting time and the very rapid burnout suggested by the manufacturers involve some risk of damage to the rapidly dried and expanded mould.

When the burnout was carried out after 1 h from investing the wax patterns (Group II), the castings were

found to be satisfactory. The castings were found oversized +0.158 % radially and +0.360 % axially. This increase in casting size would facilitate comfortable placement of the casting on the prepared tooth and also would provide space for the cementing medium. This finding was substantiated by many authors like Anusavice and Kenneth [5], Craig and Robert [6], Rossensteil et al. [7], Peregrina and Schorr [8], Engler et al. [9], etc. Though the castings of this group in this study was found to be slightly oversized when compared to Group III but still this group of castings was considered to be the best as this slight overextension was necessary to compensate for the shrinkage which takes place during the porcelain firing procedures. This has been substantiated by Shelby in his study on Practical considerations and design of porcelain fused to metal

When the burnout was carried after 2 h (Group III), the castings were found to be satisfactory. This finding has been advocated by Lacy et al. [3], who have stated that patterns should be allowed to bench set in 50 % relative humidity for 2 h prior to burnout.

When the burnout procedure was carried out after 24 h (Group IV) and 3 days (Group IV) from investing the wax pattern the castings were found to be lightly undersized. If the moulds are to be stored for an extended period, maximum dimensional stability is probably ensured by keeping them in 100 % relative humidity, to replenish the lost water, particularly if gypsum bonded investment are used [3].

Subjecting the investment to burnout after 1 h from the time of investing the wax patterns, in a pre heated furnace where the temperature was already at 900 °C (Group VI) resulted in castings which exhibited maximum shrinkage compared to all other groups. The investment also showed some cracks during the burnout procedure. Too rapid heating causes cracking of the investment according to Osborne [10]. In such a case outside layer of the investment becomes heated before the centre portions. Consequently the outside layer starts to expand thermally resulting in compressive stress in the outside layer, counteracting tensile stresses in the middle regions of the mould. Such a stress distribution causes the brittle investment to crack from the interior outwards in the form of radial cracks. These cracks, in turn, will produce a casting with fins and spines.

The castings obtained with the split ring (Group VII), were slightly oversized and were found to be unsatisfactory. This is in approximate conformity with findings of Jenkins [11]. It was found that axial discrepancy was greater (almost double) than the radial discrepancy for the oversized castings. The finding was supported by Anusavice [5] who states that the expansion of the investment is always greater in the unrestricted direction (longitudinally) than in lateral direction, towards the ring itself.

To sum up the discussion, the casting which is optimally oversized is always recommended. Depending upon the alloy, the casting has to be slightly oversized to compensate for the thermo cycling shrinkage during ceramic firing.

Conclusion

Following conclusions were drawn from this study:

1. Castings produced by subjecting the invested wax patterns to burnout after 20 min; after 24 h and after 3 days were found to be undersized.
2. Castings obtained by burnout of invested wax patterns in a pre heated furnace were also undersized.
3. The castings obtained by use of a split ring were oversized.
4. The castings obtained by subjecting the invested wax pattern to burnout after 2 h were satisfactory.
5. The castings obtained by subjecting the invested wax patterns to burnout after 1 h was found to be the best among all the experimental groups.

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