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Comparative Evaluation of the Marginal Accuracy of Four Different Types of Pattern Waxes in Complete Cast Crown- An In Vitro Study

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Abstract

Introduction: Precise marginal seating is more important in dental restoration to fulfill biological, physical and cosmetic requirements. The accuracy of wax pattern is of major significance for obtaining a well fitting casting. Improper marginal fit has been identified as a cause of failure of cast restorations.

Aim: To evaluate and compare the marginal accuracy of four different types of pattern waxes in complete cast crown.

Method: 40 impressions were made from the stainless-steel master die, using an addition silicone impression material (Dentsply) with a custom acrylic tray. Wax Patterns were fabricated using 4 different pattern waxes namely Kronenwachs 40111 Blue (Bego Company-Group 1), Thowax Sculpturing Wax (Yeti dental company-Group 2), Modelling Wax Ivory No 8420560 (DFS Diamon Company-Group 3), Sigmadent Company(Group 4) on 40 working stone dies obtained from master die. Marginal gaps were measured in four locations using an optical microscope with image analyzer at 100x magnification. The software used was la32, LECO, USA.

Results: ANOVA test revealed a significant difference between different waxes with respect to mean distance. There was statistically significant difference for marginal discrepancy values for Group 3 (DFS) and other pattern materials ($p < 0.05$). However no statistacilly significant difference was seen with marginal discrepancy values of Group 1(Bego), Group 2 (Yeti) and Group 4 (Sigmadent).

Conclusion: Modelling Wax ivory no 8420560 (DFS Company-Group 3) was found to be most accurate pattern wax than that of other pattern waxes tested for marginal discrepancy.

Keywords: pattern waxes, marginal discrepancy, optical microscope, image analyser , dental waxes.

Introduction

Precise fit of the restoration margin to the preparation finish line is necessary to prevent gingival inflammation,

secondary caries and is an important indicator of the overall acceptability of the cast restoration [1,2].

The accuracy of wax pattern is of major importance for obtaining a well fitting casting. However, dental waxes have greater co-efficient of thermal expansion, which may be a major contributing factor to the inaccuracy of the final restoration. Dimensional changes in wax pattern occur on the die and during removal of pattern from the die. It is observed that pattern removed from die after initial carving and remodeling at the margin after replacement on the die has a more acceptable fit[3]

A cast dental restoration is fabricated by forming a pattern on a stone working die that can be removed and embedded in a refractory mold material from which it is eliminated by the use of heat and is casted. Traditionally, wax has been used as a pattern material

Many methods for measuring marginal fidelity includes four basic categories, these are

1. Direct view
2. Cross sectional view
3. Impression techniques
4. Explorer / visual examination[4].

The present study, used 'Direct View' method, by virtue of its nondestructive nature . It is often used to monitor stepwise distortion. Direct view technique is easy, convenient and rapid. It is carried out with the help of optical microscope[4.]

The purpose of this in vitro study was to evaluate and compare the marginal accuracy of four different types of pattern waxes namely Kronenwachs 40111 Blue (Bego Company), Thowax Sculpturing Wax (Yeti dental Company), Modelling Wax Ivory No 8420560 (DFS Diamon Company), Sigmadent Company by keeping the die, impression material and die stone constant. The evaluation of marginal accuracy is carried out by using traveling microscope.

The study was intended to determine the choice of the type of pattern wax that best suits our purpose of minimizing marginal discrepancy found in various casting restorations.

Materials and Method

Materials used in the Study.

1. Pattern Wax. (Fig.1)

a) Kronenwachs 40111 Blue (Bego Company)

b) Thowax Sculpturing Wax (Yeti dental company)

c) Modelling Wax Ivory No 8420560 (DFS Diamon Company)

d) Sigmadent Company

Figure 1: Pattern Waxes

2. Die lubricant (Sigmadent Company, INDIA)

3.Impression Material:- Polyvinyl Siloxane Addition Siloxane (Dentsply)(Fig. 2)

Figure 2: Polyvinyl Siloxane (Dentsply)

4.Diestone (Ultra Rock)(Fig. 3)

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Figure 3: Die Stone (Ultra Rock).

5.Autopolymerising Acrylic Resin (DPI)

Armamentarium used in the Study

1. Magnifying glass (Fig. 4)
2. Wax bath (Confident)(Fig. 5)
3. P. K. Thomas waxing kit.(Fig 6)
4. Optical Microscope (LECO, USA) (Fig.11)

Figure 4: Magnifying glass

Figure 5: wax bath

Figure 6: P. K. Thomas waxing kit

Method

The method used for this study can be described under following heading :

1. Preparation of the master model (fig. 7) in stainless steel
2. Duplication of stainless steel die
3. Preparation of wax patterns
4. Measurement of marginal discrepancy.

1. Preparation of the master model

A stainless steel master die was made to simulate single tooth preparation for crown.

The master die was machined on a milling machine with a shoulder of 90^0 and 1 mm in width. It had a total axial taper of 6^0, axial height of 6mm; occlusal diameter of 6mm; occlusal slot for correct wax pattern repositioning ; reference marks were scribed on the margin of master die at four sites 90 degrees apart . These marks were the sites to verify reseating of wax pattern on master die and evaluate vertical marginal discrepancy.

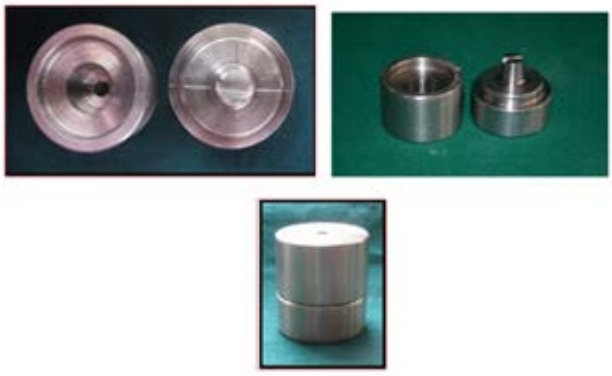

Figure 7: Master Model in stainless steel.

A stainless steel wax pattern forming assembly was used to fabricate standardized wax patterns for crowns. This assembly was fabricated to accurately fit on the shoulder of the master model (die). The die could be accurately and snugly positioned in a stainless steel wax pattern forming assembly like the lid of container. The wax pattern forming assembly was kept 1mm larger than the die

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dimensions. A hole of 4mm diameter was prepared in the wax pattern forming assembly on the top portion (lid like portion).

2. Duplication of stainless steel die

40 impressions were made from the stainless-steel master die, using an addition silicone impression material (Dentsply) with a custom acrylic tray as shown in (Fig 8)[5,6,7].

High-strength dental stone (Ultra Rock) was used to make 40 working dies from the master die (Fig 9). The working dies were then allowed to set for 1 hour.

Figure 8: Fabrication of Custom Tray and Impression Procedure for Stone Die Fabrication.

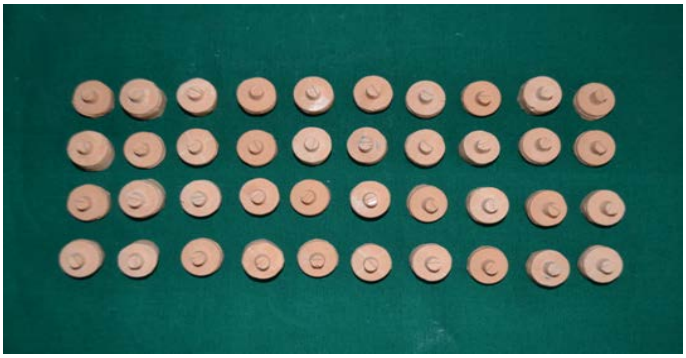

Figure 9: Stone Dies.

3. Preparation of the wax patterns-

40 wax Patterns were prepared for this study (Fig.10) the waxes used to form the patterns were,

- Kronenwachs 40111 Blue (Bego Company)
- Thowax Sculpturing Wax (Company)
- Modelling Wax Ivory No 8420560 (DFS Diamon Company)
- Sigmadent Company

The Stone die and wax pattern forming assembly were coated with wax isolating microfilm (Aurofilm).

Wax patterns were made manipulating each wax as per manufacturers instruction by the same operator. A wax pattern forming assembly was used to standardize the amount or thickness of pattern material [6, 8]

Figure 10: Wax patterns fabricated on stone die

4) Measurement of Marginal Discrepancy

After 1 hour from the beginning of fabrication, the patterns were seated by the same operator on the master die using light finger pressure until resistance was met[5]. Marginal gaps were measured by the same operator in four locations using an optical microscope with image analyzer at 100x magnification (Fig.12). The software used was la32, LECO, USA, in the R&DE Ministry of Defense. It reveals the discrepancies in the marginal fit of the wax pattern on the master die at microscopic level. Measurements were made at four reference marks on the die.

Figure 11: Optical Microscope

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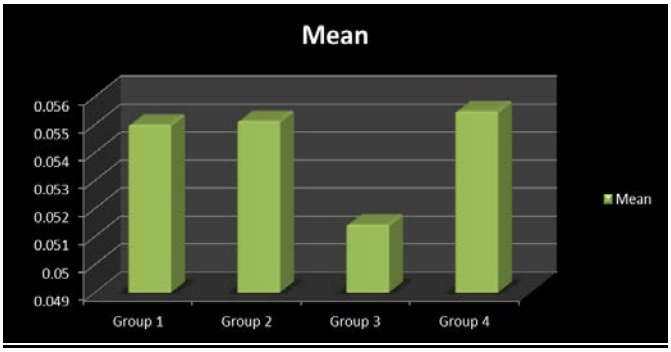
Results

By using ANOVA test p-value was 0.034mm, therefore there is significant difference between Group 1, Group 2, Group 3 and Group 4, with respect to mean distance.



Minimum distance found in Group 3 with mean 0.0504mm (± 0.0032mm) and maximum distance found in Group 4 with mean 0.05143mm (± 0.0044mm), p-value table for pairwise comparison of mean distance in group Group 1, Group 2, Group 3 and Group 4. (Table 1)

ANOVA test

	N	Mean	SD
Group 1	40	0.055	0.00688
Group 2	40	0.05513	0.00608
Group 3	40	0.05143	0.0045
Group 4	40	0.05548	0.0047

p - value = 0.034

Pair wise comparison

By using tuckey's test

SITE A	Group 1	Group 2	Group 3	Group 4
Group 1	-	0.498	0.0068	0.079
Group 2	-	-	0.0061	0.379
Group 3	-	-	-	0.0054
Group 4	-	-	-	-

Table 1

In the pair wise comparison it was found that p- value for group 1 and group 2 , group1 and group 4 , group 2 and group 4 are greater 0.05 hence there was no statistically significant difference between mean discrepancy among group1, group2 and group 4.

However p value for group1 and group3, group2 and group3, group 3 and group 4 was less than 0.05, hence there was statistically significant difference between mean discrepancy group1 and group3, group2 and group3, group 3 and group 4.

Discussion

The marginal fit is important for long term success of cast restorations. Deficiencies can result in damage to the teeth and periodontal structures. Retention of plaque leads to marginal inflammation as well as gingival recession. Insufficient marginal fit can cause secondary caries below the margins of the crown. These defects are frequent reasons for failure of the restorations.

The fabrication of acceptable wax patterns is an important variable that can affect marginal fit throughout the casting procedure. Proper manipulation with a thorough understanding of its properties and nature will help in fabrication of acceptable wax pattern.

Generally the basic constituents of dental waxes come from three main sources, Mineral- eg. Paraffin wax, microcrystalline wax or ceresin, Insect- eg. Beeswax, Vegetable - Carnauba wax, Candelila wax, Resins and gums[9]

Paraffin waxes are mixtures of chiefly straight-chain saturated hydrocarbons which crystallize in plates or needles. Litene and barnsdahl have better micro-hardness than other hydrocarbon waxes. Montan waxes are obtained from various lignites, but unlike the other mineral waxes they are mixtures of long-chain esters accompanied by high molecular weight alcohols, acids and resins. As a result, montan wax is hard and brittle[10].

Carnauba and ouricury waxes are composed of a mixture of straight-chain esters, alcohols, acids and hydrocarbons. They are characterized by high hardness, brittleness, and high melting points. Candelilla wax, although a plant wax, contains 40-60 percent paraffin hydrocarbon accompanied by esters, alcohols and acids. Japan wax is primarily a fat containing glycerides of palmitic, stearic and other higher molecular weight acids[10].

Beeswax, which is a complex mixture of esters, consists mainly of myricyl palmitate plus saturated and unsaturated hydrocarbons and organic acids. It is supplied in a number of grades, the bleached type being of higher purity[10].

The selection of waxes, therefore, include wide range of sources, composition and properties. Properties of these

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waxes will control to a great extent the combination used for various applications in dentistry.

The paraffin wax exhibits a setting range between 51.5^0 C - 53.0^{0}C. This is the lowest setting range amongst the mineral waxes . Barnsdahl had the highest setting range 85.0^0 C - 87.0^0 C. Ceresin is an exception , with the setting range between 52.0^0 C - 73.0^0 C. Both yellow and bleached bees wax has a setting range between 61.0^0 C - 63.0^0 C[51].

It was observed in a study that marginal gaps for samples prepared with both direct & indirect method ranged from 7 to 46 µm and are within the range of clinical acceptability[5.] In current study, the indirect wax Patterns method was used because of convenience provided by the indirect method. In Indirect technique, the property of wax flow is less critical, also the pattern may be removed from the die at a lower temperature and with greater ease.

Examining the marginal fit of patterns on the master die before investing allows evaluation of pattern material at this stage of fabrication. The marginal gaps were measured on the master metal die 1 hour after its fabrication on the stone working die made from addition silicone impression. Removal of pattern from the die causes dimensional changes in average elevations of 29 to 56 µm depending on the load applied before removal. The crown patterns were placed with finger pressure instead of using a jig capable of exerting a standard load for specific period of time. The disadvantage of using a jig being it may cause breakage of delicate pattern waxes while measuring the marginal discrepancy[5].

In this study, the crown wax patterns were examined after 1 hour because according to Phillips, the maximum time that wax patterns can be stored at room temperature without noticeable distortion of the casting is 1 hour[11].

In the current study, the mean readings as per statistical analysis were as follows (Table 2):

Group 1	Group 2	Group 3	Group4
0.055 ± 0.00688	0.05513 ± 0.00608	0.05143 ± 0.0045	0.05548 ± 0.0047

Table 2: Units in mm

From the statistical analysis, it can be concluded that there is statistically significant difference for marginal discrepancy values for Group 3 (DFS) and other pattern materials ($p < 0.05$). However no statistacilly significant difference was seen with marginal discrepancy values of Group 1(Bego), Group 2 (Yeti) and Group 4 (Sigmadent).

According to this study, the marginal discrepancy is least with Group 3 (DFS pattern wax). Group 1 (Bego pattern wax), Group 2 (Yeti pattern wax) and Group 4 (Sigmadent pattern wax) were almost in the same range.

Marginal discrepancy values with Group 1 (Bego pattern wax), Group 2 (Yeti pattern wax) and Group 4 (Sigmadent pattern wax) may be higher due to release of internal stresses. This may be due to the composition of the wax, which is a mixture of various waxes having different melting points.

Modelling Wax ivory no 8420560 (DFS Company) has melting temperature of 55.4 ^{0}C, this can be attributed to higher content of paraffin wax in its composition. Thowax Sculpturing Wax (Yeti Dental Company) has melting temperature 57.3^{0}C,the probable reason for this can be predominance of ceresin in its composition , Sigmadent Company has melting temperature 48^{0}C, the predominance of japan wax might be the probable cause for this melting range. Kronenwachs 40111 blue (Bego Company) has melting temperature 61^{0}C, this might have resulted due to ceresin content in the inlay wax. These are just suppositions as the exact composition of waxes is a highly guarded by the manufacturers.

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However it is found that the waxes don't have a melting point but a melting range, therefore release of internal stresses is inevitable.

Waxes have low thermal conductivity, so it is difficult to achieve uniform heating. When the wax is sufficiently warmed and cooled later , release of stresses will occur resulting in distortion.

Dental waxes have greater co-efficient of thermal expansion than any other materials used in dentistry. Shrinking of wax pattern occurs on the die and during removal of the pattern from the die. Patterns removed from the die after initial carving and remodeling at the margin after the replacement on the die has more acceptable fit[9].

The polymerization shrinkage of impression material and the expansion of the stone die are also directly associated factors that affect the marginal fidelity. The polymerization shrinkage of impression material and the expansion of the stone die can also result in non uniform bulk of wax pattern resulting in release of unequal stresses & ultimately contributing to error in observations for marginal discrepancy, as the bulk of the material in the fabrication of crown patterns was standardized using counter metal die. However, no attempt was made to investigate these factors in this study, as it was out of the scope of the present study[9].

When adapting wax to stone or some metal dies, some form of lubricant must be used to release the wax pattern from the die. These fluids produce a separator film of minimum thickness. However this thickness is difficult to control & increase in thickness can contribute to marginal discrepancy.

In a study it was concluded that light polymerized resins, autopolymerising resins & diacrylate resins are better options for pattern making, but still waxes are extensively used due to ease of manipulation and cost effectiveness[5].

Recently, dental CAD/CAM (Computer-Aided-Design/Computer-Aided Manufacturing) system techniques have been gaining importance for fabricating metal or ceramic crowns. Tsutihara used such a technique to fabricate a wax pattern for crown casting . Since the cement space to abutment can be set up beforehand in a CAD/CAM system, it is possible to make an oversized wax pattern of a size to accommodate the amount of casting contraction[12].

BEGO's new CAD/CAM production center takes open scanner STL files to produce Selective Laser Melting (SLM) for BeCe Waxup resin crown and bridges. SLM, a form of rapid-prototyping or stereolithography that uses laser technology to melt wax into thin layers, is used in all BEGO production centers. The layers are melted together to create homogeneous copings patterns. In short they convert open scanner STL files into wax/resin coping or bridges that ship back ready for spruing, investing, pressing or casting.[13].

According to this study, the marginal discrepancy is least with Group 3 (DFS pattern wax). Group 1 (Bego pattern wax), Group 2 (Yeti pattern wax) and Group 4 (Sigmadent pattern wax) were almost in the same range.

This may be due to the composition of waxes resulting in different:- 1) release of residual stresses 2) thermal conductivity 3) range of coefficient of thermal expansion 4) polymerization shrinkage of impression materials 5) expansion of dies tone die etc.

Other factors which could have affected the outcome of final restoration would be 1) die spacer 2) lubricating agent 3) setting expansion of investment 4) casting ring 5) pickling solution 6) oxidation of copper from alloy 7) different casting pressure 8) difference in heating of alloy 9) air entrapment and other casting defect.

Stresses are easily induced in forming any pattern; in fact, the formation of a completely stress-free wax pattern would appear improbable. However, with knowledge of

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the physical characteristics of the wax, an operator can minimize the stresses in the pattern by applying the appropriate manipulative procedures[14]. Use of CAD CAM or resin patterns are the valuable alternatives but even then waxes continue to be the pattern making material.

Conclusion

Within the limitations of this study, it was concluded that

1. Amongst the four pattern waxes tested for their marginal discrepancy the Modelling Wax ivory no 8420560 (DFS Company) was found to be most accurate pattern wax than that of Thowax Sculpturing Wax(Yeti Dental Company), , Sigmadent Company, Kronenwachs 40111 blue (Bego Company) .
2. The pattern wax which produce the best marginal accuracy was found to be Modelling Wax ivory no 8420560 (DFS Company).

References

1. David Assif, Racha Antopolski, Michel Helft, Isreal Kaffe "Comparison of Methods of Clinical Evaluation of the Marginal Fit of Complete Cast Gold Crowns". J Prosthet Dent 1985; 54(1): 20-24.
2. Ivy S. Schwartz "A Review of Methods and Techniques to Improve the Fit of Cast Restorations". J Prosthet Dent 1986; 56: 279-283
3. Rafael Grajower, Israel Lewinstein. "Effect of Manipulative Variables on the Accuracy of Crown Wax Patterns". J Prosthet Dent 1985; 53(2): 168-172
4. John A. Sorensen. "A Standardized Method for Determination of Crown Margin Fidelity". J Prosthet Dent 1990; 64(1): 18-24.
5. Alan Iglesim, John M. Powers, Hugh P. Pierpont, "Accuracy of Wax, Auto Polymerized, and Light-Polymerized Resin Pattern Materials". Journal of Prosthodontic, 1996; 5 (3): 201-205.
6. Efstratios Konstantoulakis, Hiroshi Nakajima Ronald D. Woody, Amp W. Miller. Marginal Fit And Surface Roughness Of Crowns Made With An Accelerated Casting Technique". J Prosthet Dent 1998; 80:337-45.)
7. Elaine R. Schilling, Barbara H. Miller, Ronald D. Woody, Amp W. Miller Iii,
   Martha E. Nunn. "Marginal Gap of Crowns Made With A Phosphate-Bonded Investment and Accelerated Casting Method". J Prosthet Dent 1999; 81:129-34.
8. R. G. CRAIG, J. D. EICK,* And F. A. PEYTON "Properties Of Natural Waxes Used In Dentistry" J. Dent. Res. November-December 1965. Vol. 44, No. 6 1308- 1316
9. E.C. Combe. Notes On Dental Materials.
10. R. G. CRAIG, J. D. EICK,* And F. A. PEYTON "Properties Of Natural Waxes Used In Dentistry" J. Dent. Res. November-December 1965. Vol. 44, No. 6 1308- 1316.
11. Anusavis, Phillip's Science of Dental Materials.
12. Hollenback and Roads "A study of behaviour of pattern waxes"J. Southcal. St.D.A. 1959;27:149
13. Miehio Ito, Toshio Yamagishi, Yoshiki Oshida, Carlos A. Munoz. "Effect of Selected Physical Properties of Waxes on Investments and Casting Shrinkage". *J Prosthet Dent 1996; 73(2): 211- 216* Craig Restorative dental materials.

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