ACCURACY AND REPRODUCIBILITY OF REVERSIBLE HYDROCOLLOIDS VERSUS ELASTOMERS DUPLICATING MATERIALS

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إن نجـاح التعويضة المعدنية المتحركة أو تعويضة زراعة الأسنان يعتمد على دقة المثال المنسوخ من المثال الأصلي، وقد قسمت الجمعية الأمريكية لطب الأسنان المواد الناسخة إلى مواد غروية ردودة وأخرى غير ردودة. ومن أكثر المواد الناسخة شيوعاً هي المركبات الفروية الردودة حيث تتميز بقوتها الكافية ومرونتها بالإضافة إلى أنه يمكن إعادة استخدامها مرات عديدة مما يجعلها أقل كلفة من المواد الناسخة الأخرى، إلا أنه من عيوب هذه المادة تغير أبعادها إذا ما عُرِّضت للماء أو للهواء وقابليتها للتحلل بالماء تدريجياً عند التخزين مما يفقدها مرونتها وصلابتها.

وهناك أنواع أخرى من المواد الطابعة كالمواد المرنة ومثال ذلك مادة البولي ايثر ومادة السليكون المطاطي. وتتميز هذه المواد بإمكانية عمل عدة أمثلة منسوخة من مثال واحد. كما يمكن الانتظار مدة من الوقت قبل صب المثال، إلا أن ارتفاع سعر هذه المواد يعتبر من أهم سلبياتها.

في هذه الدراسة تم تقييم دقة أبعاد وإعادة إنتاج أربع مواد مختلفة من المواد الناسخة وهي:

نوع من الفرويات الردودة، نوع من البولي ايثر، ونوعان من بولي فينيل سيلوكسان.

عمل عينة قياسية من الفولاذ بتجاويف أفقية وعمودية مختلفة العمق والعرض حسب مواصفات الجمعية الأمريكية لطب الأسنان حيث بلغت أبعادها ٧٦ × ٧٦ × ٥ , ٩مم، ومن ثم عملت نماذج سلبية لهذه العينة بالمواد الناسخة الآنفة الذكر حسب إرشادات الشركات المصنعة لها ثم صبت هذه النماذج بالمسحوق الكاهي للحصول على نماذج مشابهة للعينة الفولاذية.

وقد تم قياس العينة الأصلية والنماذج المماثلة والبالغة إثنتا عشر قالباً بجهاز تحليل السطوح ومن ثم حللت النتائج إحصائياً.

وقد أظهرت نتائج هذه الدراسة أن:

١ ـ مادتي البولي فينيل سيلوكسان والبولي ايثر أكثر دقة مقارنة بمادة الفروبات الردودة.

٢ ـ عدم وجود اختلافات هامة بين المواد التي تم دراستها.

The dimensional accuracy of four duplicating materials, including one brand of agar reversible hydrocolloid, one brand of polyether rubber, and two brands of polyvinyl siloxane (addition silicone) rubber was studied. A standard stainless steel specimen of 76 x 76 x 9.5 mm was made. Vertical and horizontal grooves were made on the specimen as reference marks. The horizontal grooves were in different depths and widths. The duplicating materials were prepared and poured over the standard die to make a negative likeness. These negatives were

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poured with the same investment material. Twelve investment specimens were measured for accuracy and detail reproduction with a Talysurf finish analyzer. Results of this study indicated that polyvinyl siloxane and polyether rubbers are superior in accuracy compared to the agar reversible hydrocolloid. No significant differences in detail reproduction were noted in any of the duplicating materials tested.

Introduction

The ultimate success of any removable metallic prosthesis or implant prosthesis is attributed to the duplicated casts which should be accurately reproduced from the master casts.[12] The duplicating materials evaluated by the American Dental Association (ADA) No. 20 were divided into thermally reversible and irreversible materials.[3]

An accurate refractory cast may be obtained when an impression of the original cast is made in an elastic material and poured with investment. The most common duplicating materials are reversible hydrocolloid compounds. The composition of these compounds is quite similar to agar impression material, but the percentage of agar is about 5% while the impression materials may contain 10-15% agar. In addition, reversible hydrocolloid duplicating material does not contain waxes, fillers and other modifiers common to impression materials.[4]

Agar duplicating materials are reversible and have adequate strength and elastic properties to make duplication of minor undercuts possible. These materials may be reused many times which makes them less expensive to use than other duplicating materials. The disadvantages of this material are its susceptibility to dimensional changes if stored in air or water. It is a polysaccharide material and will gradually hydrolyze at storage temperature with an eventual loss of elasticity and strength.[14]

Other types of elastomeric materials, such as silicone rubber and polyether, are used recently as duplicating materials. The advantages of these elastomeric materials over reversible agar duplicating materials are that multiple casts can be made from a single mold and it is possible to wait for an extended period of time before pouring the mold with the investment materials.[56] They are considerably more expensive to use than the agar material but are preferred by some laboratories for making multiple casts from the same mold.

This study compared the accuracy and detail reproduction of four types of duplicating materials.

Materials and Methods

Four duplicating materials were used: a Castogel* agar reversible hydrocolloid, Reprogum** polyether, Elite Doublet and Wirosiltt polyvinyl siloxane (addition silicone) eslatomers.

A stainless steel die was made according to ADA specification No. 20 [Fig. 1] and was 76 x 76 x 9.5 mm. On the highly polished surface of the die, two vertical lines (F_1 and F_2) were made with a diamond indenter. These reference marks were made 19 mm from each edge for the linear dimensional change test. Another 14 horizontal lines of varying depth and width were made for testing the reproduction of details. These horizontal lines were parallel to each other, 2.5 mm apart, at right angles to the lines F_1 and F_2 [Fig. **11.**

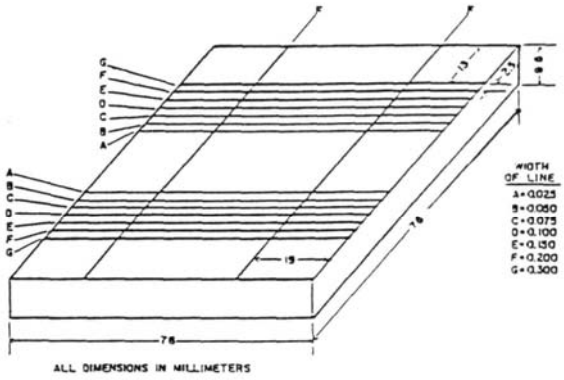

Figure 1. Schematic diagram of the stainless steel die specimen.

* Bego, Bremen, Germany
** ESPE, Premier, Germany
t Zhermack Rovigo, Italy
tt Bego, Bremen, Germany

Agar reversible hydrocolloid was prepared according to the manufacturer's directions. It was poured into a plastic duplicate container over the metal die at 40° ± 2°C. The thickness of this duplicating material was 6 mm. It was placed in a cooler* for 60 minutes to allow indirect proper cooling. Polyvinyl siloxane and polyether duplicating materials were mixed at room temperature (22° ± 2°C) according to the manufacturer's instructions. The base and catalyst were mixed in the ratio of 1:1 until a homogenous color was obtained. Then it was poured in a thin stream into a plastic duplicate flask over the metal die. The thickness of these duplicating materials was 4 mm. [Fig. 2]. Each duplicating material was separated from the metal die after it has set. All die molds were poured with the same dental investment material** following the manufacturer's instructions. The investment mix was mechanically spatulated for 60 seconds in a vacuum mixer.t The investment samples were allowed to set for one hour before separation from the molds. Three investment specimens were made for each duplicating material.

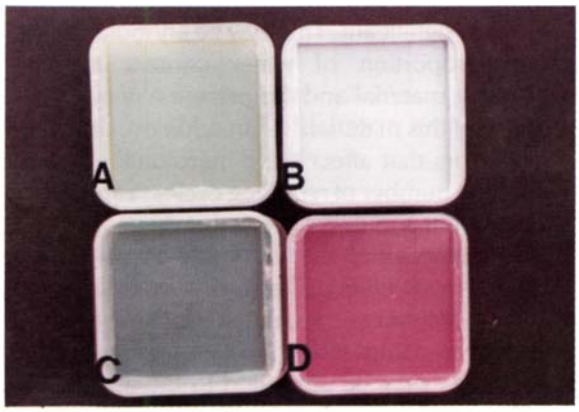

Figure 2. Moulds of the different type of duplicating materials: (A) Reprogum, (B) Wirosil, (C) Castogel and (D) Elite Double.

The master stainless steel die and the investment specimens that corresponded to the different types of duplicating materials were measured with a Talysurf surface analyzer+t [Fig. 3]. For the linear dimensional shrinkage change test, the distance between the reference points (F_1-F_2) was measured. Detail reproduction was determined by measuring the width and depth of the horizontal lines. The Talysurf surface finish analyzer was connected to a computerized printer machine. The computer printouts contained all the measurements recorded from the stylus which contacts the specimens to record all dimensions (depth, width and length). These computer printouts were assessed to the nearest millimeter. The results were collected, tabulated and statistically analyzed using Student-Newmen-Keuls Sequential Range Test (SINK Test) and analysis of variance (ANOVA).

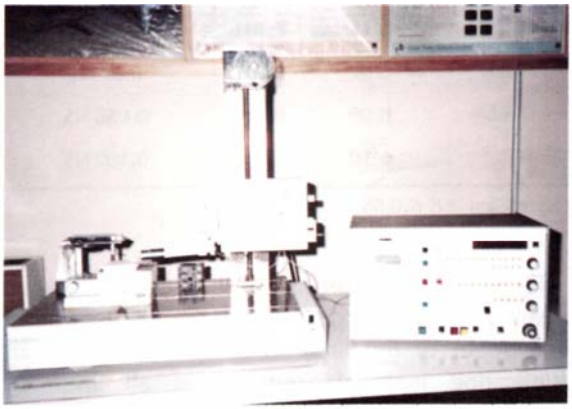

Figure 3. A photograph showing the Talysurf surface finish analyzer.

Results

Tables 1 and 2 and Figures 4 and 5 represent the results of this investigation. Table 1 and Figure 4

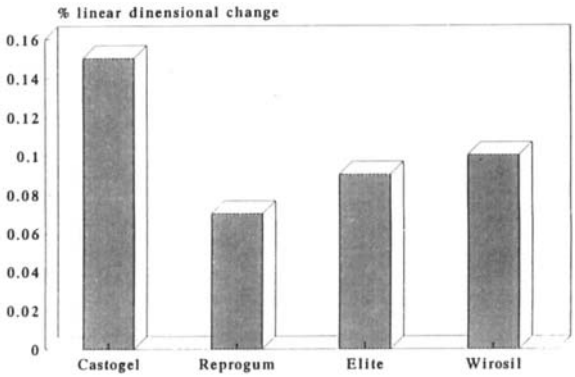

Figure 4. Linear dimensional changes of the duplicating materials.

*** Friger, Bego, Bremen, Germany**
**** Wirovest, Bego, Bremen, Germany**
t Degussa, Frankfurt, Germany
tt Rank Taylor Hobson Company, UK

present the arithmetic means and standard deviations of the percentage of linear dimensional change of the investment specimens obtained from the molds of the duplicating materials.

The results of this study indicate that only agar reversible hydrocolloid has a significant change in linear dimensional change compared to the master specimen in the form of a contraction ($P < 0.05$). Student-Newman-Keuls Sequential Range Tests were performed as indicated in Table 1.

Table 1. *Linear dimensional change (%) of investment specimens obtained from different duplicating materials.*

Materials	Mean %	Standard Deviation %	Student Newman-Keuls Sequential Range Test
Castogel	0.15	0.018	0.152*
Reprogum	0.07	0.015	0.07 NS
Elite Double	0.09	0.013	0.088 NS
Wirosil	0.10	0.012	0.100 NS

* Significant at P =S 0.05
NS = Not significa ntat5% level.

Table 2 and Figure 5 present the arithmetic means and standard deviation of the average width and depth of the lines in millimeter. The four duplicating materials reproduced all lines of different widths and depths. The results indicated no significant difference in detail reproduction among the four duplicating materials ($P < 0.05$).

Table 2. *Mean widths and depths of lines (in mm) prepared on the standard metallic specimen and those reproduced from different duplicating materials.*

Variables	Width in mm		Depth in mm	
	X	SD	X	SD
Metallic specimen	0.2883	0.1227	0.0636	0.0323
Castogel	0.2357	0.1345	0.0350	0.0278
Reprogum	0.3143	0.1345	0.0579	0.0336
Elite Double	0.3321	0.1390	0.0593	0.0284
Wirosil	0.4386	0.1410	0.0467	0.0261
"F" value	0.6102 NS		1.0574NS	

X: Mean
SD: Standard Deviation
NS: Not significant at 5% level ($P <= 0.05$)

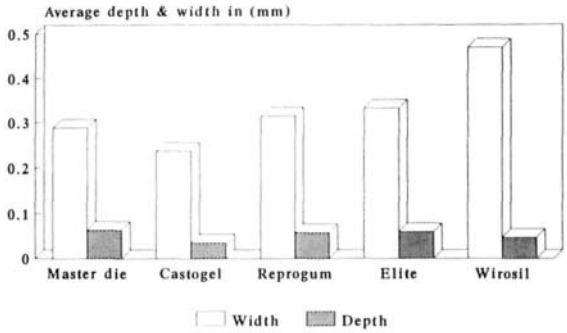

Figure 5. Average widths and depths of lines of the specimen and the duplicating materials.

Discussion

The most important characteristics of any dental duplicating material should include high accuracy, exact reproduction of details, controllable dimensional changes, good flow ability and easy removal and handling.

A comparison of the linear dimensional change of the duplicating materials evaluated in this study illustrates that Castogel (agar reversible hydrocolloid) has a greater linear dimensional change in the form of contraction which is statistically significant. This may be attributed to the greater proportion of water content in agar duplicating material and the presence of syneresis property of this material.[1,4,7] In addition, there are other factors that affect the dimensional stability, such as the number of reboiling cycles, variation of water content and delay in pouring.[8,9]

On the other hand, the specimens obtained from Reprogum (polyether), Elite and Wirosil (addition silicone materials) indicated no significant difference as compared to the standard specimen. This stability may be attributed to the absence of volatile reaction products, such as water and alcohol.[10,11,12]

According to the detail reproduction test, the results indicated that all duplicating materials have fine detail reproduction ability. Although Elite double (addition Silicone) and Reprogum (polyether) showed superior means for detail reproduction than Castogel (agar) and Wirosil (addition silicone), there was no statistically significant difference among the four duplicating materials.

This study supports the findings of Herring *et* a/[13] that no difference existed in the accuracy among

the addition silicone and polyether impression materials. Herfort *et al*[9] found that the addition silicones have the smallest change followed by polyether impression material, however. In other studies[15,16] polyether impression materials gave some expansion during setting which resulted in under-sized dies.

Conclusions

The accuracy and detail reproduction of four different types of duplicating materials were assessed. The authors conclude that further studies are essential to investigate the difference of the other factors affecting duplicating materials as performed with impression materials, such as time of pouring,[14] the effect of bulk on accuracy,[13] and elastic recovery.[17]

The findings of this study indicated that polyvinyl siloxane and polyether duplicating materials are superior in accuracy than agar reversible hydrocolloid duplicating materials. However, the four materials studied provided fine reproduction ability without significant difference among them.

References

1. Craig RG. Restorative dental materials. 8th ed. St. Louis:CVMosby, 1989:307-08.
2. Williams EO, Hartman GE. Compatibility of reversible hydrocolloid duplicating materials and dental stones. J Prosthet Dent 1984;52:699-703.
3. Council on Dental Materials and Devices. American Dental Association Specification No. 20 for dental duplicating materials. J Am Dent Assoc 1978; 1.
4. Craig RG, Peyton FA. Physical properties of elastic duplicating materials. J Dent Res 1960; 39:391 -401.
5. Craig RG. Review of rubber impression materials.) Mich Dent Assoc 1977;58:254-61.
6. Stackhouse JA Jr. The accuracy of stone dies made from rubber impression materials. J Prosthet Dent 1970;24:377-86.
7. Marget PM, Hansen WC. changes in agar-agar type duplicating material and agar-agar on heating and storage. J Am Dent Assoc 1957;54:737-43.
8. Klooster J, Logan Gl, Tjan AH. Effects of strain rate on the behavior of elastomeric impression. J Prosthet Dent 1991;66:292-98.
9. Duke BR, Ryge G. Properties of laboratory duplicating materials. D Prog 1961 ;1:88-93.
10. Phillips RW. Skinner's science of dental materials. 9th ed. Philadelphia:WB Saunders Co, 1991:146-47.
11. Hembree JH Jr, Nunez Lj. Effect of moisture on polyether impression materials. J Am Dent Assoc 1974,89:1134-36.
12. Leinfelder KF, Lemons JE. Clinical restorative materials and techniques. Chicago:Lea & Febiger, 1988:181-86.
13. Herring HW, Tames MA, Zardiackas LD. Comparison of dimensional accuracy of a combined reversible/ irreversible hydrocolloid impression system with other commonly used impression materials. J Prosthet Dent 1984;52:795-99.
14. Herfort TW, Gerberich WW, Macosko CW, Goodkind RJ. Viscosity of elastomeric impression materials.) Prosthet Dent 1977;38:396-404.
15. Eames WB, Sieweke JC, Wallace SW, Rogers LB. Elastomeric impression materials: effect of bulk on accuracy. J Prosthet Dent 1979;41:304-07.
16. Williams PT, Jackson DG, Bergman W. An evaluation of the time dependent dimensional stability of eleven elastomeric impression materials. J Prosthet Dent 1984;52:120-25.
17. Craig RG, Gehring PE, Payton FA. Aging characteristics of elastic duplicating compounds. J Dent Res 1962;41:196-206.