Dimensional accuracy of removable dies made from Pindex® system as a function of sectioning time

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تقترح المقالات المتوفرة على أن الجبس السني يتعرض للتمدد الموحد الخواص. ويبلغ التمدد حده الأقصى (٧٠٪) خلال ساعتين بعد بدء المزج وتتابع القيمة تزايدا خلال الأربع وعشرين ساعة التالية. تشمل هذه الدراسة مقارنة تشوه الأبعاد الخطي لأجزاء الطبعة المتحركة المحضرة بنظام بريندكس والمجزأة خلال ثلاثة فترات زمنية تراوحت من ساعة ونصف إلى أربع وعشرين ساعة. تم تحضير تسعين طبعة من المثال الأساسي المصنوع من مادة الطبع سيليكون المتعدد الفينيل (ريبروسيل) والنوع الرابع من الجبس السني (إكساليبور). تمت تجزئة المثال الأساسي خلال ثلاثة فترات زمنية، ساعة ونصف وساعتين وأربع وعشرين ساعة بدءا من عملية صب الجبس. تم تحديد المسافة الخطية بين الدعامتين بواسطة المجهر المتنقل ومقارنتها مع المثال الأساسي. أجري التحليل الاحصائي باستخدام تحليل أنوفا وبوست هوك (α = ٠,٠٥). أشارت النتائج إلى أن التشوه الخطي نتيجة لتمدد الجبس لم يكن مهما بعد ساعة ونصف (٠,٠٠١) بالمقارنة بعد ساعتين وأربع وعشرين من صب الطبعة.

Existing literature has indicated that dental stone after mixing undergoes continuous isotropic expansion. The maximum expansion (70%) of dental stone occurs approximately after 2 hours from the start of mix and the value progressively increases in the following 24 hours. **OBJECTIVE:** This study compared the linear dimensional distortion of removable dies made from Pindex® system sectioned at 3 time intervals ranging from 1.5 hours to 24 hours. **MATERIALS** and **METHODS:** Ninety impressions were made of a metal master model with polyvinyl siloxane impression material (Reprosil) and poured in Type IV dental stone (Excalibur). The master casts were sectioned at 3 time intervals: 1.5 hours, 2 hours and 24 hours from the start of mix for the first pour. The linear distance between the two abutments were made with traveling microscope and compared with the master model. Data were analyzed with one-way ANOVA / Tukey post hoc test (α = 0.05). **RESULTS:** The results indicated that sectioning the master cast of Pindex® system at 1.5 hours showed significantly less linear distortion due to expansion of the gypsum (P<.001), compared with those sectioned at 2 hours and 24 hours from the start of mixing stone for the first pour.

INTRODUCTION

The master cast with removable dies on which a fixed partial denture or implant supported fixed prostheses is fabricated must be accurate and dimensionally stable over time. However, the linear expansion of dental stone causes inaccuracy in the spatial positioning of the abutments from the oral cavity to the master cast.

Dental stone after mixing undergoes an initial phase of contraction followed by progressive expansion during the change from hemihydrate to dehydrate state.[1,2] This phenomenon is both volumetric and linear. In a dental setting, a value is determined for linear setting expansion and an assumption is made that expansion is isotropic.[3] Montignoni and Schoneberger[4], and Heshmati *et al*.[5] reported that the maximum expansion (70 %) of stone occurs approximately after 2 hours from the start of mix and the value progressively increases during the following 24 hours and gets essentially completed at 96 hours. The magnitude of expansion is related to the volume of mass of the cast.[3] Thus, the greater the volume or mass of the cast, the greater is the linear expansion. For this reason, it is desirable to interrupt the continuity of expansion of the master cast by sectioning before 2 hours to reduce its volume and minimize progressive linear expansion.[4]

The time elapsing from the beginning of the mix of dental stone until the material hardens is known as setting time.[1] The minimum time allowed for setting varies from 30 minutes to 60 minutes. Most modern dental stone products reach

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a ready-to-use state in 30 minutes.[1] For polyvinyl siloxane impression material, it is generally recommended to remove the cast from the impression after approximately 60 minutes, if maximum tensile strength of the stone is to be achieved. The indexing base made in dental stone needs only 30 minutes to be ready for use. Thus, a double pour cast for removable dies could be sectioned approximately by 90 minutes.

Several concepts and techniques have been used to make accurate removable dies,[6-12] the Pindex®* system being one of them which is popularly used.[13] The Pindex® technique consist of placing the dowel pins after the cast had set and subsequently fabricating stone indexing base and sectioning it. The other systems such as Zeiser®** and DVA®*** eliminate stone indexing base and replace it with a plastic base. The systems claim that elimination of the stone indexing base increases the accuracy of the removable dies.[6,9,10]

Serrano *et al*.[9] studied 4 removable die systems: (1) Stainless steel pins with indexer system; (2) Pindex® system; (3) DVA® system and (4) Conventional brass dowel pin system‡. Impression for Pindex system and stainless steel pin with indexer system were poured in dental stone and allowed to set for 24 hours. The casts were stored for another period of 24 hours and then sectioned. They concluded that when sectioned dies were compared with the master model, the linear dimension of all 4 die systems was greater than 0.055 mm of the master model.

Aramouni and Millstein[6] evaluated the reproducibility of die position using two removable die systems: Pindex® and Zeiser® system with the solid cast. The stone casts were separated from their impressions after 24 hours and stored at room temperature. The casts were sectioned after 72 hours and evaluated. They concluded that Zeiser® system was significantly more accurate than the solid cast, which was significantly more accurate than the Pindex® system.

One study[10] compared the accuracy of three techniques used to fabricate master casts for implant prostheses. The techniques included Pindex® and Zeiser® system and solid cast. The casts made from Pindex® system were removed from the impression after one hour and stored for 24 hours before sectioning. They reported that casts made from Zeiser® system were significantly less distorted than solid casts, or those made with the Pindex® system.

Wee *et al*.[12] investigated the linear dimensional accuracy of implant casts fabricated from three die systems: Pindex® system, DVA® system, and die tray system§. The casts were allowed to set for 1 hour before removing from their impressions and stored in ambient temperature for at least 24 hours before sectioning. They reported that sectioned casts produced with die tray system were significantly less accurate than those produced with either the Pindex® or DVA® system.

Sectioning the casts reported by these investigators, although it represents a great advantage, an attempt to reduce the setting expansion of stone as a function of time was not taken into consideration. The pins were placed after 24 hours by which time more than 70 percent of expansion of the cast had resulted.[4] Little importance has been ascribed in the reported studies to the sectioning time of the master casts. It is therefore desirable to know how much of dimensional distortion is inherent in the Pindex® system when the cast is sectioned at different intervals of

* Coltene Whaledent, Inc., Mahwah, NY, USA
** Zeiser System, Girrbach Dental, Santa Rosa, CA,USA
*** DVA, Dental Ventures of America, Corona, CA, USA
‡ J.M. Ney Corp., Bloomfield, CN, USA

§ KO Trays, Vident Inc., Brea, CA, USA

time from the start mixing the stone for the first pour.

The purpose of this study was to compare the linear dimensional distortion of removable dies made from Pindex® system sectioned at 90 minutes (1.5 hours), 2 hours and 24 hours from the start of mixing the dental stone for the first pour.

MATERIALS AND METHOD

A machined stainless steel model containing two full-crown preparation dies was used as a master model to simulate three-unit fixed partial denture abutments. Reference lines were inscribed on top (cross hairs) of the two metal abutments for measuring purpose. The metal base carried two metal rods; one on either side of the abutment dies. The stainless steel abutment dies were attached to metal base in their indexed holes by means of screws (Fig. 1). The abutment dies were 11 mm apart from each other as this was considered to be the average mesiodistal width of the lower second molar.[14]

Light cure acrylic resin custom trays were fabricated following manufacturer's instructions with three millimeter space between the metal model and acrylic resin tray. The acrylic resin tray had two indexed holes corresponding to two metal rods of the base to permit the tray to seat in the same position on the metal base each time an impression was made. The metal rods of the metal base permitted the impression to be removed vertically. A deformation of impression material by tilting the tray when removing it was thus avoidable. The custom trays were stored at room temperature for 24 hours before making impressions.

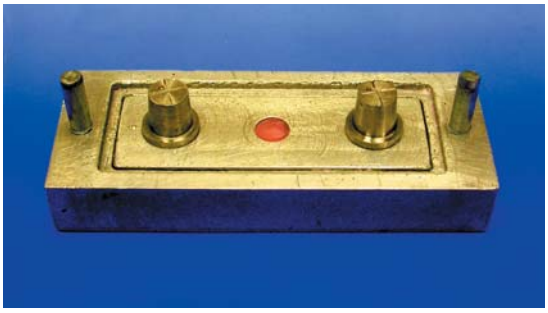

Fig. 1. Standard metal model with two abutments.

Ninety individual impressions were made with custom trays using polyvinyl siloxane impression material♦. The impression surface of the custom tray was painted with adhesive supplied by the manufacturer and allowed to dry for 15 minutes. All impressions were made using automatic mixing device supplied by the manufacturer. The light body material was injected around the metal abutments. The putty impression material was mixed by hand following the manufacturer's recommended proportions and loaded in the custom tray. The custom tray was seated over the metal model until the impression tray with the metal base made a firm contact and the metal rods of the metal base were completely seated in their corresponding holes of the custom tray. The assembly was subjected to 1 kg seating force and was allowed to set for 12 minutes from the start of mixing time at room temperature of 25 ± 2°C and relative humidity of 55± 10%. According to the American Dental Association Specification No. 19,[15] the manufacturer's setting time was doubled to compensate for delayed polymerization reaction compared with that at mouth temperature.

Set impressions were removed from the master model and carefully inspected for inaccuracies, folds and voids under a stereozoom microscope® at 10x magnification#. Defective impressions were discarded and replaced. The impressions were sprayed with Lubrofilm®x surfactant and allowed to set for 10 minutes and

♦ President®, Coltene, AG, Alstatten, Switzerland
Bauseh and Lomb, Scientific Optical Products Division, Rochester, NY, USA

any excess was then gently blown off with compressed air.[16]

CONSTRUCTION OF WORKING CASTS

All 90 impressions were poured once using Excalibur®[xx] type IV dental stone. As recommended by the manufacturer, 100 grams of powder and 23 milliliters of distilled water were used. The powder was weighed in electric balance▪ to an accuracy of 0.1 gram and distilled water was measured to an accuracy of 0.1ml using a pipette. The material was hand mixed for 15 seconds then mechanically spatulated under vacuum at 25 psi/Hg for 30 seconds with Vac-u-vestor machine□. The mixed dental stone was added to the impression in small increments placed on the vibrator and allowed to set for 1 hour (first pour) to obtain a master cast. The master casts were then separated from the impressions and each master cast with its base was trimmed so that the inferior and superior surfaces were flat and parallel to each other.

PINDEX SYSTEM®

Two parallel pin holes were drilled onto the underside of the master casts for each removable die section. The debris from the pin holes was removed using compressed air. Brass dowel pins were then cemented into the drilled holes with cyanoacrylate resin. Super Sep◊ Stone separating medium was sprayed onto the base and allowed to dry for 10 minutes. The plastic sleeves were placed on the brass dowels before pouring the base.

The master casts were boxed to a size of 20 mm x 60 mm x 20 mm using boxing strip wax○ to a height of 10 mm from the underside of the master cast. Type IV dental stone Excalibur® was mixed as previously described. The base was poured over the boxed master cast base and allowed to set for 30 minutes.[1]

A manual die saw was used to section the cast. The loose gypsum debris was removed from the dies and the cast with a soft brush and compressed air. The dies were later removed and seated 30 times to evaluate stability of the segments to simulate the handling during laboratory procedure. The dies were carefully replaced before measurements.[9,11,12]

The ninety casts were divided into 3 groups of 30 each. The groups were designated from 1 through 3 according to the time intervals selected for sectioning elapsing from the start of mixing time of the stone for the first pour. Group 1 cast was sectioned after one hour and 30 minutes, Group 2 was sectioned after 2 hours, and Group 3 after 24 hours.

MEASURING TECHNIQUE

The measuring locations on the top of the stone dies (cross hairs) were on the same level for each master cast to facilitate accurate linear measurements between the two dies. To ensure that casts were positioned on the same relative plane, they were rebased before measurements.[17]

The undersurface of the base of the cast was made wet in water and 4 small mounds of plaster were placed on the underside to form a stable plane, and the cast was inverted onto a glass slab (Fig. 2). A horizontal bubble level* was placed on the surface of the cast (Fig. 3). A light finger pressure was applied until the air bubble was centered in the middle of the level and the plaster was allowed to set.[9]

[x] Lubrifilm, Dentaurum, Pforzheim, Germany
[xx] Excalibur, Garreco Inc., Heber Springs, AR, USA
▪ Mettler PE 3600, Delta Range, Allied Fisher Scientific, Loughborough, England
□ Whip Mix Corp., Louisvilli, KY, USA
◊ Super Sep, Kerr, Romulus, MI, USA
○ Boxing Wax, Hygienic Corp., Akron, Ohio, USA
* Empire Magnetic Polycast Torpedo Level, Empire Level Mfg. Corp., Mukwonage, WI, USA

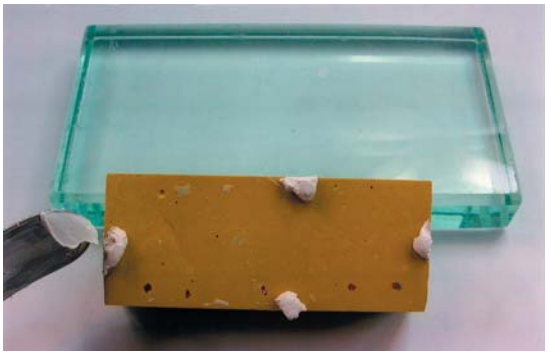

Fig. 2. Mounds of plaster placed on the underside of the base of the cast.

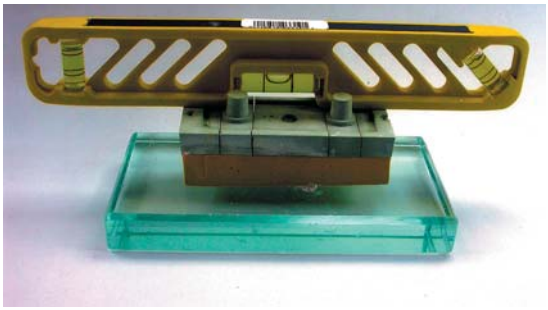

Fig. 3. Horizontal bubble level placed over the cast. The air bubble was centered in the middle of the level so that the top surface of the dies was in the same plane.

The distance between the cross hairs on top of the metal dies was measured to the nearest of 0.0001 inch under low power at a 20 degrees angle incidence to the surface illumination with α 30 magnification using a traveling microscope**. Five measurements between the cross hairs on top of the metal dies were made, and the average was calculated to be 0.9436 inch. The same distance on each master cast was measured 3 times by one operator. The average of the 3 measurements was calculated to yield one value. The mean linear distance deviation from the metal die for each master cast was calculated. The percentage dimensional change was calculated by dividing the mean linear distance deviation from the metal die for master cast by the mean linear distance of the metal die and multiplying the resultant value by 100.[18]

The data were analyzed using one-way analysis of variance (ANOVA). Tukey post hoc test was employed if ANOVA showed significant difference. All hypothesis testing was conducted at α = 0.05. The data were analyzed with the SPSS Statistical Package***.

Table 1. The Linear setting expansion values of Type IV dental stone master cast sectioned at 3 time intervals (%)

Time intervals	Linear Setting of expansion		Range	Mean	SD*
	Minimum	Maximum			
1.5 hours	0.003	0.066	0.063	0.035	0.019
2 hours	0.034	0.087	0.052	0.066	0.016
24 hours	0.140	0.204	0.063	0.169	0.020

*SD = Standard Deviations

RESULTS

Expansion data of master casts sectioned at 3 time intervals are presented in percentage deviation from the master metal model in Table I. The highest percentage of linear dimension expansion between the two dies was observed at 24 hours (0.169%), followed by 2 hours (0.066%) and the least at 1.5 hours (0.035%). Forty percent of the total expansion occurred before 2 hours had elapsed and 21% of the total expansion at 1.5 hours. After 2 hours the expansion was continuous up to 24 hours. Analysis with one-way ANOVA indicated a statistically significant difference among the three groups (F_2, 87 = 414.7; P<0.0001). Further analysis with Tukey's post-hoc multiple comparison procedure revealed that percentage linear expansion of the three groups was significantly (P<0.0001) different from one another.

** Measuring Microscope 3800, Titan Tool Supply Co. Inc., Buffalo, NY

*** SPSS, Version 10.0, SPSS Inc., Chicago, IL

DISCUSSION

It is important to control the progressive setting expansion of dental stone in the fabrication of removable dies. Several investigators[2,4,5] have reported that continuous setting expansion of dental stone was essentially complete by 24 hours. In this study, the removable stone dies made using Pindex® system were sectioned at 3 time intervals from the start of mix for the first pour to study the setting expansion as a function of time. The master casts sectioned at 24 hours showed significantly (P<0.0001) higher mean linear expansion value (0.0169%) compared with those sectioned at 2 hours (0.066%) and at 1.5 hours (0.035%). All the three groups were significantly (P<0.0001) different from one another.

The minimum linear dimensional change required by the material to pass the ANSI/ADA Specification No. 25 should not exceed 0.10% for Class IV dental stone at 2 hours.[18] The value for the mean linear expansion at 2 hours (0.066%) observed in this study remained close to the ANSI/ADA Specification suggesting that the dental stone used in the present study is dimensionally accurate. However, the dental stone exhibited progressive expansion after 2 hours up to 24 hours while the material was setting (Table I). In this study, the total expansion at 2 hours was 40%. Heshamati *et al*. [5] studied linear setting expansion of 6 Type IV dental stones to compare their expansion from 10 minutes to 120 hours. They reported that the total expansion at 2 hours ranged from 22% to 71% and the continuous expansion was essentially complete at 24 hours. They further concluded that the amount of linear expansion varied significantly among the materials.

The findings of the present study could not be directly compared with the previous studies[4,5,12] because specimens from previous studies were made with different brands of Type IV dental stone and were sectioned at varying time intervals ranging from 48 to 72 hours. The mean linear expansion value of the present study (0.66%) at 2 hours was comparable to the previous study[9] (0.056%) at 48 hours, although the sectioning time intervals was different. One of the reasons could be that the investigators [9] used Silky-Rock dental stone* which had the lowest setting expansion (0.00%) compared to other brands of Type IV dental stones and 67% of its total expansion had occurred before 2 hours.[5]

It is important to interrupt the continuous expansion of dental stone while setting in the fabrication of removable dies using Pindex® system. The ideal time of sectioning the cast as demonstrated by the present study was at 1.5 hours that showed the lowest linear setting expansion (0.035%). The dimensional change of the removable dies is generally reported in 3 dimensions. However, in this study, only linear expansion was evaluated. Another limitation of this study was that only 1 brand of gypsum was evaluated. Further investigation of linear expansion with various brands of dental gypsum is needed.

CONCLUSIONS

The following conclusions were drawn from the results of this study. Compared with the master model, the mean linear expansion values between the removable dies made with Pindex® system and sectioned at 3 time intervals, 1.5 hours, 2 hours and 24 hours respectively from the start of mix for the first pour, were significantly different from one another.

A low linear expansion value was obtained when the master cast was sectioned at 1.5 hours from the start of mix for the first pour.

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