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Evaluation of Accuracy of Impression Materials with Different Mixing Techniques

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Evaluation of Accuracy of Impression Materials with Different Mixing Techniques

by

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A Dissertation submitted in partial satisfaction of
the requirements for the degree
Master of Science in Prosthodontics

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Each person whose signature appears below certifies that this thesis in his/her opinion is adequate, in scope and quality, as a dissertation for the degree Master of Science.

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The following is list of people who have shared a great deal of their personal time to shape me into the person that I am today. Without them, this research project and the learning experiences would never have occurred for me.

To Drs. Winer, Kattadiyil, and Khatami, I want to humbly thank each one of you for being my committee members and making great sacrifices to helping me complete this research project. I greatly appreciate the guidance, time and effort that you have all invested in me during my prosthodontic residency and beyond to help me find my own path.

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CONTENTS

TABLES

Tables Page

FIGURES

Figures Page

ABSTRACT OF THE DISSERTATION

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by

James Ywom

Advanced Specialty Education Program in Prosthodontics
Loma Linda University, School of Dentistry, March 2013
Dr. Mathew T. Kattadiyil, Chairperson

Purpose: To investigate gypsum compatibility and dimensional stability of irreversible hydrocolloid impression materials with three mixing techniques. A comparison between vacuum-mixed, mechanically-mixed and manually-mixed techniques was evaluated for each impression material.

Materials and Methods: Three irreversible hydrocolloid impression materials Kromopan 100® (Lascod™), Identic® (Dux dental™), and Jeltrate Plus® (Dentsply™) were tested gypsum compatibility in accordance with ANSI/ADA Specification No. 18 for alginate impression materials. The test for linear dimensional stability was tested in accordance with ANSI/ADA Specification No. 19 for elastomeric impression materials. A One-way ANOVA test was used to analyze dimensional stability at a significance level of ($p < 0.05$).

Conclusion: The vacuum mixing technique facilitates the mixing of irreversible hydrocolloid impression materials and improves the compatibility with gypsum material and reproduces a more dimensionally accurate cast than the other mixing techniques.

CHAPTER ONE

INTRODUCTION

Irreversible hydrocolloid impression material is routinely used for the purpose of reproducing hard and soft intraoral tissues. The gypsum compatibility and the dimensional accuracy of the cast used to fabricate the cast are crucial for diagnostic and treatment planning purposes. In addition, the fabricated casts are valuable for the purposes of evaluating prosthetic space, diagnostic wax patterns for treatment planning and fabrication of resin based prostheses. Recently, several dental manufacturers have introduced electronic rotary devices to facilitate mixing of irreversible hydrocolloid impression materials. With regard to impression making techniques, very few contemporary studies exist.

The objectives for these in-vitro studies were to (1) evaluate gypsum compatibility of irreversible hydrocolloid impression materials mixed with mechanical and manual techniques in accordance with specification outlined in ANSI/ADA Specification No. 18, and (2) evaluate dimensional stability of casts produced from different mixing techniques in accordance with specification outlined in ANSI/ADA Specification No. 19.

The null hypotheses tested were: (1) there is no difference in gypsum compatibility between the impression material and mixing technique, and (2) there is no difference in dimensional stability between the impression material and the mixing techniques.

CHAPTER TWO

LITERATURE REVIEW

Irreversible Hydrocolloid

Irreversible hydrocolloid impression material was first introduced to the dental community in the 1940's [1]. The marine plant derived alginic acid was developed in response to a rapidly declining supply of agar impression material during World War II. The low cost and simplicity of the material made irreversible hydrocolloid the material of choice. The combination of water and impression material makes impression making easy. The fabrication of orthodontic appliances, removable partial dentures, radiographic templates for computerized tomography, and pick-up impressions for denture repair are made possible with casts fabricated from irreversible hydrocolloid impression material.

Irreversible hydrocolloid impression material is made when water and alginate salts react to form insoluble hydrocolloids. A colloid is best described as any combination of a solid, liquid, or gaseous material that form together as one part suspension and the other as particulate. When the two components are mixed together they form a larger matter, a colloid. In the case of irreversible hydrocolloids impression materials, when water is introduced, the water becomes the suspension and, as the impression materials sets, the particulates of alginic polymers and fillers conform together to form the hydrocolloid.

The term irreversible refers to the chemical reaction that occurs when potassium alginate, a soluble gel, reacts with water to form calcium alginate, an insoluble gel. The

chemical reaction subsequently forms a cross-linked fibrillar polymer network, which ultimately forms the set irreversible hydrocolloid impression material. The chemical reaction sequence for the gelation process is displayed in Figure 1.

Potassium alginate + Calcium sulfate dehydrate + Water → Calcium alginate gel + Potassium sulfate

Sodium phosphate (s) + Calcium sulfate (s) → Calcium phosphate (aq) + Sodium sulfate (aq)

Potassium Alginate (aq) + $CaSO_4$ → K_2SO_4 (aq) + Calcium Alginate (insoluble)

Figure 1: Chemical reaction sequence

Non-reactive constituents like diatomaceous earth and zinc oxide provide strength to set impression material. To extend the working time, sodium phosphate is added to retard the chemical reaction between potassium alginate and calcium alginate. The difference between fast setting and regular setting impression materials is determined by controlling the sodium phosphate content. Once the impression is set, potassium titanium fluoride is found on the surface of the impression material which accelerates the setting of gypsum while it is in contact with the impression surface. A summary listing of components for irreversible hydrocolloid impression material is outlined in Table 1.

Table 1: Composition of irreversible hydrocolloid impression material[1]

Component	Function	Weight (%)
Potassium alginate	The soluble alginate that dissolves in water and reacts with calcium ions to form the gel.	15
Calcium sulfate	Has a strong affinity for alginate cations and forms the insoluble calcium alginate gel	16
Zinc Oxide	Filler particles	4
Potassium titanium fluoride	A salt added to accelerate the setting of gypsum when it contacts the impression surface.	3
Diatomaceous earth	Filler particles added to increase strength of the set impression material. Also added to control consistency and create a smooth surface texture.	60
Sodium phosphate	Retarding agent used to set the setting time.	2

Impression Mixing Techniques

Factors for properly mixing irreversible hydrocolloid impression materials for accuracy begin when the chemical reaction is initiated between the impression material and water. Skinner, Cooper, and Beck[2] were one of the first authors to write about the mixing technique and its effect on the overall physical properties of irreversible hydrocolloid impression materials. Their investigation found that one of the factors which control the strength of irreversible hydrocolloid impression material is the content of water during the gelation period. Too much water resulted in a dimensionally weakened impression material and extended the setting time. The second factor was

"underspatulating" the impression material during the mixing phase that resulted in a weakened material because the ingredients of the impression powder did not react appropriately. The third factor was the accuracy of the gelation time of the impression material, because the sensitivity of the gelation time was markedly affected by temperature of the water which altered the impression material to gel faster or slower. A slight alteration in the water/powder ratio or water temperature dramatically changed the setting time and the overall strength and accuracy of the completed impression. An importance pointed by the authors was that regardless of the materials being used, clean instruments are vital to accuracy of dental materials.

Reisbick et.al.[3] was one of the first studies to incorporate a vacuum-mixing unit in the evaluated 9 types of gypsum materials with 3 irreversible hydrocolloid impression materials. One of the factors for accurately reproducing surface detail was the production of a smooth impression surface. The authors stated that properly loading the tray with the impression material and avoiding entrapment of air was critical for overall accuracy. In an effort to maintain a smooth impression surface, the mixing technique outlined in their study was the incorporation of a vacuum-mixer, Whip-mix combination unit (Whip-mix, Louisville, KY). The impression material was first mixed with water in a rubber mixing bowl, and then transferred to a separate vacuum mixing bowl and mixed under a vacuum for 15 seconds using the Whip Mix combination unit at 425 rpm at 27in Hg pressure.

For comparisons between manual and mechanical mixing techniques, Frey et. al.[4] evaluated elastic recovery, compression strength and compression strain of irreversible hydrocolloid impression materials. A comparative analysis between manually-mixed versus mechanically-mixed impression materials found that there was an improvement in

elastic recovery and compression strength of the mechanically mixed impression material. The improvement in elastic recovery and compression strength was attributed to the fact that mechanically-mixed irreversible hydrocolloid impression material was easier to use because of the "bubble-free" surface texture. In addition to their finding, the improved viscosity of the mechanically mixed impression material, improved the overall consistency when compared to the manually-mixed technique.

Inoue et. al.[5] investigated the setting and flow characteristics of alginate impression materials after the material were mixed by three different techniques. Included in their study was a comparative analysis between, manually-mixed, combination manual and mechanically-mixed, and automatically-mixed irreversible hydrocolloid impressions. It is thought that impressions made by rotary instruments possessed flow properties superior to manually mixed techniques. The automated mixing apparatus described in this study was a double rotation mechanical mixer with a plastic, cone-shaped mixing container. In their study, they found that the advantage of a high speed, automated mixing apparatus provided a fine paste with very little air bubble content. Impression materials mixed with mechanical-type mixers created a lower viscosity impression composition when compared to manually-mixed impression materials. However, they also found that an apparent disadvantage is the reduced working time of the impression material. The overall improvements found in this study resulted in an impression material mixed with the automated mixer resulted with a higher compressive gel strength and gel fracture. The automated mixing technique was effective in improving the gel strength and gel fracture, because the mixing technique eliminated "air bubbles in the set material".

Gypsum Compatibility

The surface texture of a cast fabricated from any dental impression material is important because it is the basis for which diagnostic information is obtained, and the quality of the prostheses fabricated from the cast is of greater value. The quality of the cast surface is largely related to the chemistry between the gypsum and impression material.

A standardized test to evaluate gypsum compatibility was conducted by Morrow et. al.[6]. The authors evaluated compatibility of four alginate impression materials with five gypsum materials available at that time. A stainless steel test block was used to compare the compatibility of different gypsum/impression combinations. Etched lines of 25 micron wide lines were scribed on the metal surface of the test block. The authors created a scoring scale from 1 to 4, which was used to categorize the gypsum/impression combinations for compatibility. A score of 1 represented a gypsum cast surface that reproduced the 25 micron line with the best detail and compatibility. A score of 4 represented a gypsum cast surface that demonstrated poor compatibility due to lack of reproducibility. A light microscope at 10X magnification was used to evaluate all test samples. Although the impression samples were all able to reproduce the 25 micron lines, there were some gypsum/impression combinations which did not accurately reproduce the 25 micron on the cast samples.

A two-part study conducted by Jarvis and Earnshaw[7, 8] further evaluated compatibility of gypsum materials with alginate impression materials. A comparative analysis of cast surfaces was evaluated for 5 dental stones and 10 different alginate impression materials. Poor cast surface texture was found among casts from

incompatible combinations. The poor surface texture was largely due to the observation of unreacted calcium sulfate hemihydrate to a depth as much as 80 microns microscopically. The evidence against this phenomenon was due to the presence of sodium sulfate at the impression material surface. The production of sodium sulfate occurs during the chemical reaction between sodium phosphate and calcium alginate. (Figure 1). The second part of their study investigated the method to improve gypsum compatibility by suggesting alteration in the chemical makeup of the impression material. The efforts to lower the concentration of the sodium sulfate at the impression surfaces, and thus improving the surface quality of the casts, the authors recommended substituting the sodium alginate with another alginic salt and thus eliminate the retarding effects.

A more recent evaluation of gypsum compatibility with brand name irreversible hydrocolloid impression material was conducted by Reisbick et. al.[9]. The methodology from this study was similar to previously mention studies. However, an important distinction to be made was that there were still issues of incompatibility among commercially available alginate and gypsum materials.

Dimensional Stability

The purpose of any dental impression is to accurately reproduce the surface being impressed. This is perhaps the most important quality of any impression material. The ability of an impression material to capture and maintain accuracy, and transfer that information onto a gypsum material is a difficult endeavor. However, all impression materials undergo some form of dimensional change due to the composition of the impression material, formation of by-products and viscodynamic changes that occur

during and after polymerization. Dimensional inaccuracy of a cast leads to errors in diagnostic information and poorly fitting prostheses.

The anticipated amount of dimensional changes varies on the impression material. However, past studies have suggested that dimensional changes are anticipated because a sudden change in temperature contracts the impression materials or there is plastic deformation of the impression during removal of the impression material. For irreversible hydrocolloids, the dimensional accuracy is largely dependent on the loss or addition of water after the gelation. One of the first studies to evaluate dimensional stability of irreversible hydrocolloid impression materials was conducted by Skinner and Pomes[10]. Since hydrocolloid impression material was predominantly a water-based impression material, the authors advocated the used of fixing agents painted on the impression surface to maintain accuracy. They observed that when irreversible hydrocolloid impression material was exposed to the air, substantial amounts of expansion and contraction of the impression material occurred. The first observed rational was due to the presence of "free water" that was found within the spaces of the impression material. Once the impression material had set, the "free-water" partially expanded the impression material. This process continued well after the gelation time. However, after the initial expansion (imbibition), the impression material underwent a process of contraction (syneresis) due to eventual evaporation of water from the impression material[11]. Due to the dynamic changes that occur over time with irreversible hydrocolloid impression materials, the time of the impression exposed to air must be minimized to obtain an accurate cast.

Cohen et. al.[12] evaluated dimensional accuracy of alginate impression materials under different storage conditions. Acceptable limits for dimensional change are from 0.1% to 0.27%[4].

CHAPTER THREE

MATERIALS AND METHODS

Three irreversible hydrocolloid impression materials were mixed with three mixing techniques equaling impression-mixing combinations. 10 test samples were made for each of the 9 impression-mixing combinations to test for gypsum compatibility and dimensional stability.

Type III gypsum (Microstone®, Whip-Mix Corporation™) and Type V gypsum (Die-keen®, Heraeus Kulzer™) were used to test gypsum compatibility and dimensional stability in accordance with Specification No. 18 for gypsum compatibility and Specification No. 19 for dimensional stability, respectively.

Impression Mixing Techniques

For each of the mixing techniques described below, separate rubber mixing bowls, metal spatulas, and vacuum mixing bowls were used to eliminate cross-contamination of impression materials.

The manual-mixing technique utilized a rubber mixing bowl and a metal spatula. Distilled water [(23±1) °C] was measured with a graduated cylinder and dispense into the rubber mixing bowl. The impression powder was measured into a paper cup using an electronic scale. A digital timer was set to monitor the mixing times for each impression mixing technique. Manual-mixing was initiated by incorporating the impression material to the water in the rubber mixing bowl. The two materials were handled carefully to

minimize the formation of dust from the impression powder. The introduction of the two materials quickly formed a paste. Using the blade of the metal spatula, the impression material was hand-spatulated against the sides of the rubber mixing bowl until a smooth, powder-free impression mixture was formed.

The mechanical mixing technique utilized the same rubber bowl and metal spatula from the manual-mixing technique. Distilled water [(23±1) °C] was measured with a graduated cylinder and dispensed into the rubber mixing bowl. Impression powder was measured and dispensed into a paper cup using an electronic scale. A digital timer was also used to monitor and maintain consistent mixing times for each mixing technique. The impression powder was incorporated with distilled water [(23±1) °C], initially with the metal spatula inside the rubber mixing bowl. The rubber mixing bowl was quickly attached to a mechanical, rotary mixing apparatus (Alginator II, Dux dental). At low speed, the rotary mixing apparatus spins the rubber mixing bowl at 265rpm. With the rubber mixing bowl attached to the rotary mixing device, the metal blade of the mixing spatula was firmly pressed against the sides of the rubber mixing bowl for the remainder of the mixing time to produce a smooth, powder free, impression mixture.

The vacuum-mixing technique utilized the VPM 2, (Whip-mix corporation) vacuum mixer. The VPM 2 mixer had programmable settings for mixing time and speed. The mixing speed was set at 265 rpm to match the mechanical mixing device, (Alginator II, Dux Dental). The reduced atmospheric pressure was not programmable and remained at 27.5 in Hg. The mixing times were adjusted to follow manufacturer's recommendations. The vacuum-mixing technique utilized a clear vacuum-mixing bowl with 2 rotary mixing blades. Distilled water [(23±1) °C] was measured and dispensed

into the bowl using a 100ml graduated cylinder. Impression powder was measured using an electronic scale and dispensed into a paper cup. The initial mixing of the two materials was manually initiated until the impression powder was incorporated with the distilled water. The vacuum-mix bowl assembly was inserted into the VPM 2 unit and pre-programmed setting for the impression material displayed on the digital monitor and the impression material was mixed. A summary of the armamentarium for each mixing technique is listed in Table 2.

Table 2: List of mixing technique instruments

Mixing technique	Armamentarium
Manual-mixing	Rubber mixing bowl
	Metal spatula
	100ml graduated cylinder
Mechanical-mixing	Alginator II, (Dux Dental)
	Rubber mixing bowl
	Metal spatula
	100ml graduate cylinder
Vacuum-mixing	VPM 2 vacuum mixing unit, (Whip Mix)
	Vacuum mixing bowl
	Metal spatula
	100ml graduated cylinder

Table 3: Impression materials

Impression material	Manufacturer	Lot number
Kromopan 100®	Lascod™	0160291137
Identic®	Dux dental™	011722
Jeltrate Plus®	Dentsply™	100731

Prior to fabrication of the samples, the irreversible hydrocolloid impression materials were stored in a closed container with the ambient environment of for 24 hours. Distilled water was used to mix the impression materials. The impression materials used for this investigation were Kromopan 100® (Lascod™), Identic® (Dux dental™), and Jeltrate Plus® (Dentsply/Caulk™). Table 4 lists the water to impression material ratio used in this study.

Table 4: Water to impression powder ratio

Impression material	Manufacturer	Powder (grams)	Water (ml)
Kromopan 100®	Lascod™	18g	40ml
Identic®	Dux dental™	12g	32ml
Jeltrate Plus®	Dentsply™	14g	38ml

Gypsum Compatibility

Irreversible hydrocolloid test samples were first fabricated by making an impression of the 3 horizontal and 2 vertical lines of the ADA/ANSI master die. The

surface of the master die consists three horizontal lines that are 20, 50 and 75 microns in width. Two vertical lines, spread apart 25mm, are 75 microns in width.

Specification No. 18 states that the mixed impression material "shall be homogenous and free from lumps and granules", and "the impression material shall impart a smooth surface to, and separate cleanly from, a gypsum cast made from a recommended brand of gypsum.[13]"

Prior to impression mixing, the ADA/ANSI master die was conditioned in a pre-heated water bath to [(35±1) °C] to simulate intraoral temperature. The impression powder was weighed electronically and distilled water was measured using a 100ml graduated cylinder. The solute and solution were mixed together using one the mixing techniques described previously. At the completion of the mixing time, the master die was briefly removed from the water bath. During this time a rigid metal support ring was adapted to the master die to provide support for the impression material and the impression material was loaded.

Table 5: Impression material mixing times

Impression material	Manufacturer	Mixing time (seconds)	Working time (seconds)	Setting time (seconds)
Kromopan 100®	Lascod™	45	105	180
Identic®	Dux dental™	30	105	140
Jeltrate Plus®	Dentsply™	60	135	210

The impression material was slightly overfilled. A metal plate was centered over the testing assembly and was slowly placed over the impression material until it seated against the metal support ring. Excess impression material was removed from the assembly and a 1-kg weight was then placed on top of the metal plate. The master die, impression material, metal plate and weight were transferred and returned to the water bath. The impression material was allowed to set three minutes past the manufacturer's recommended setting time in accordance with Specification No. 18. The impression was carefully separated and each test sample was removed and was inspected to evaluate whether the lines for detailed reproducibility were met. Each specimen was examined under the LABSCO microscope at 10X magnification to visually confirm the reproduction of the 20 micron line.

An impression test sample that did not reproduce the 20 micron line was discarded and remade. Only samples which clearly reproduced the entire 20 micron line of the ADA/ANSI master die were used to fabricate the cast specimens.

Two gypsum materials were used in this study for gypsum compatibility. For each impression material and mixing technique test sample that reproduced the 20 micron line, type III and type V gypsum materials were tested.

Table 6: Dental gypsum materials

ANSI/ADA classification	Gypsum name	Manufacturer	Lot number
Type III	Microstone® Golden	Whip Mix Corporation™	027071001
Type V	Die-keen® Green	Heraeus Kulzer™	1009177

The gypsum materials were mixed using manufacturer's recommendations. Distilled water was measured using a 100ml graduated cylinder and dispensed into a vacuum mixing bowl. Pre-packaged gypsum materials were dispensed into a paper cup and measure electronically. The gypsum material was introduced to the distilled water and was manually mixed to facilitate the incorporation of water to gypsum powder. The gypsum material was vacuum mixed for 30 seconds at 27.5 Hg with the VPM 2 vacuum mixer, (Whip-Mix Corp).

The gypsum test sample was separated from the impression material test sample 1 hour past the manufacturer's recommended time. The 50 micron line was evaluated for gypsum compatibility using the LABSCO microscope at 10X magnification.

The grading criterion for gypsum compatibility described by Owen in 1986 was utilized to score the gypsum test sample.[14] The score system is listed in Table 7.

Table 7: Scoring scale[14]

Score	Description	Image
1	50 micron line reproduced clearly and sharply over the entire 25mm length. This is the best appearance.	
2	Line clear over more than 50% of length, line appears to be reproduced well over the entire length, smooth, but not sharp.	
3	Line clear over less than 50% of length, or line visible over the entire length but blemished and rough, and/or not sharp.	
4	Line not reproduced over entire length, rough, blemished, pitted. This is the worst appearance.	

Dimensional Stability

To measure the test for dimensional stability, the 50-micron line of the gypsum test sample was measured at 30X magnification. The 25mm distance between the two 75-micron vertical lines reproduced on the gypsum test sample was measured with a traveling microscope (Mitutoyo toolmakers Microscope®, MITUTOYO America Corporation™). At 30X magnification, it was difficult to perfectly align the 50 micron line of the gypsum test sample with the crosshairs of the traveling microscope. As a result, the linear distance between the two points was designated with a y-coordinate and

z-coordinate. The linear dimension change of the 50 microns of the gypsum test sample was calculated using the Pythagorean Theorem.

$$x^2 + y^2 = z^2$$

x, horizontal line, *y*, vertical line, *z*, hypotenuse

Linear dimensional change:

$$x = \sqrt{(z^2 - y^2)}$$

The linear dimensional change was then calculated using the formula outlined in the ANSI/ADA specification no. 19:

$$\Delta l = 100(x_1\text{-}x_2) / x_1$$

x_1, measure distance on the ADA/ANSI master die

x_2, measure distance on the gypsum cast

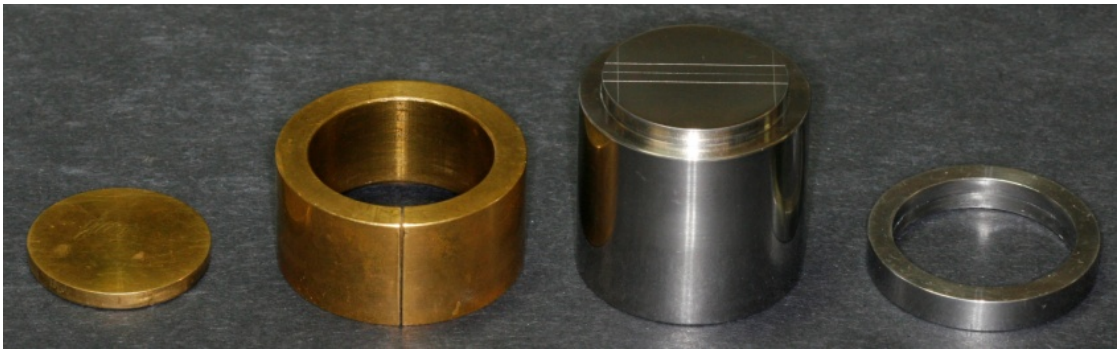


Figure 2: The ANSI/ADA Specification No. 18 Testing Apparatus
From left to right

A. Brass plate
B. Brass slit mold
C. Test die
D. Test ring mold

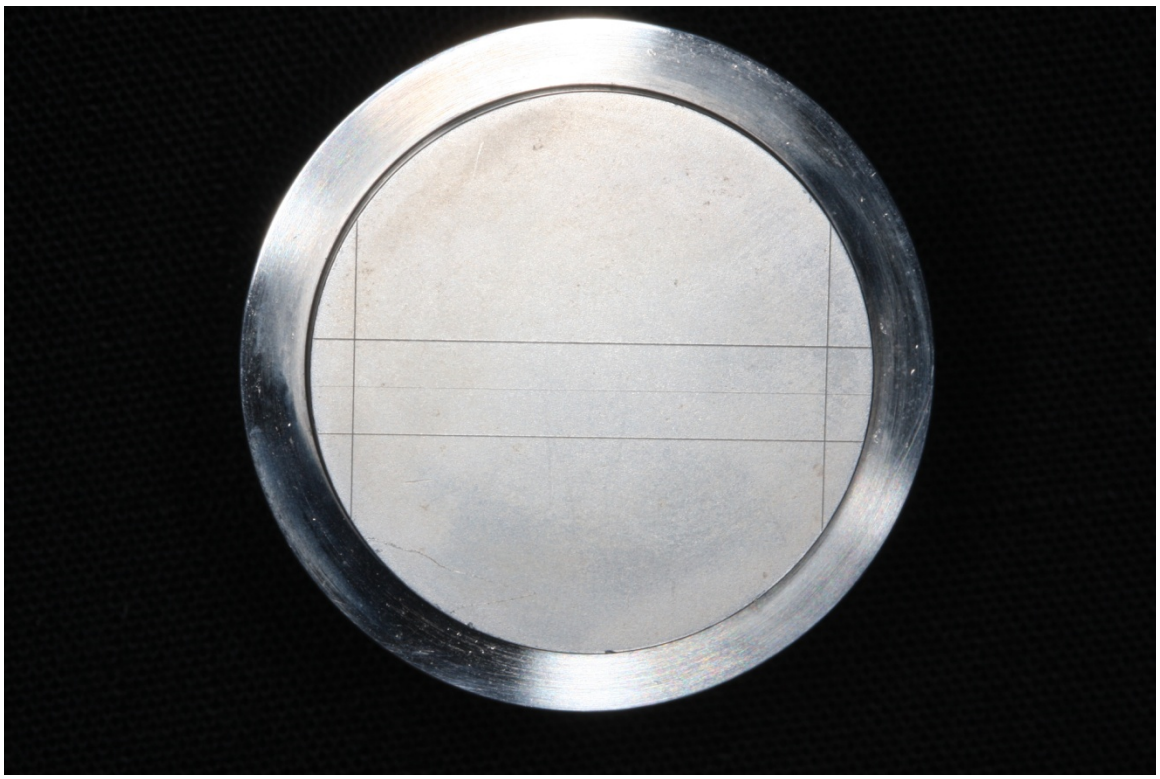


Figure 3: Surface of the ANSI/ADA Specification No. 18 die

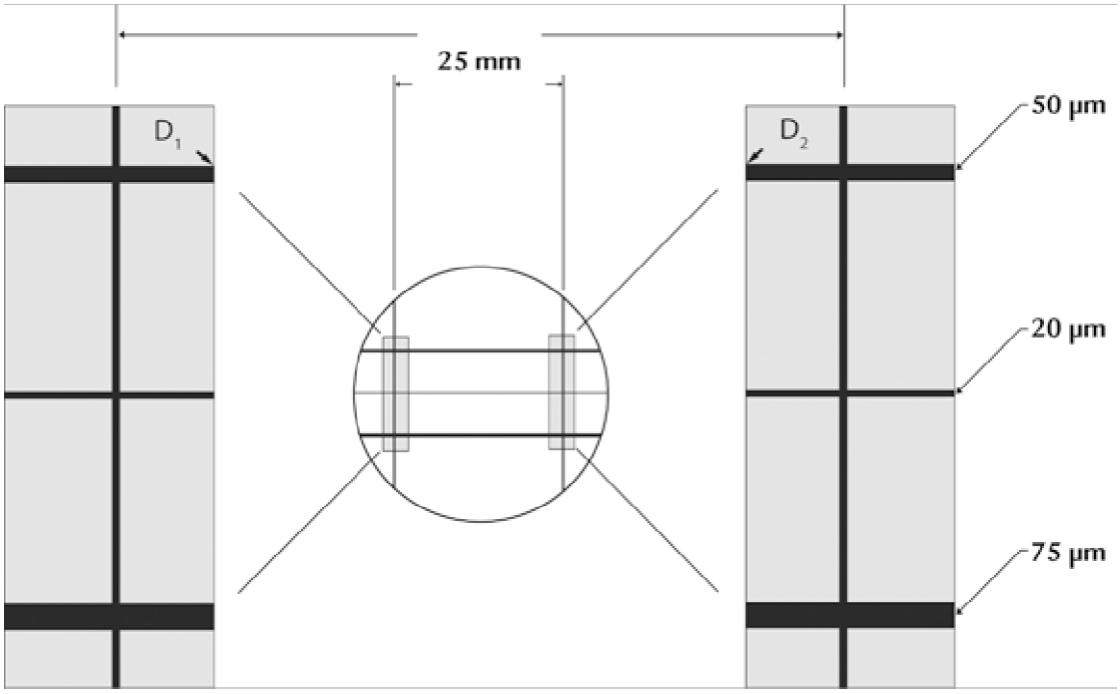


Figure 4: Schematic drawing of the dimensions of the ANSI/ADA Specification No. 18 die surface.

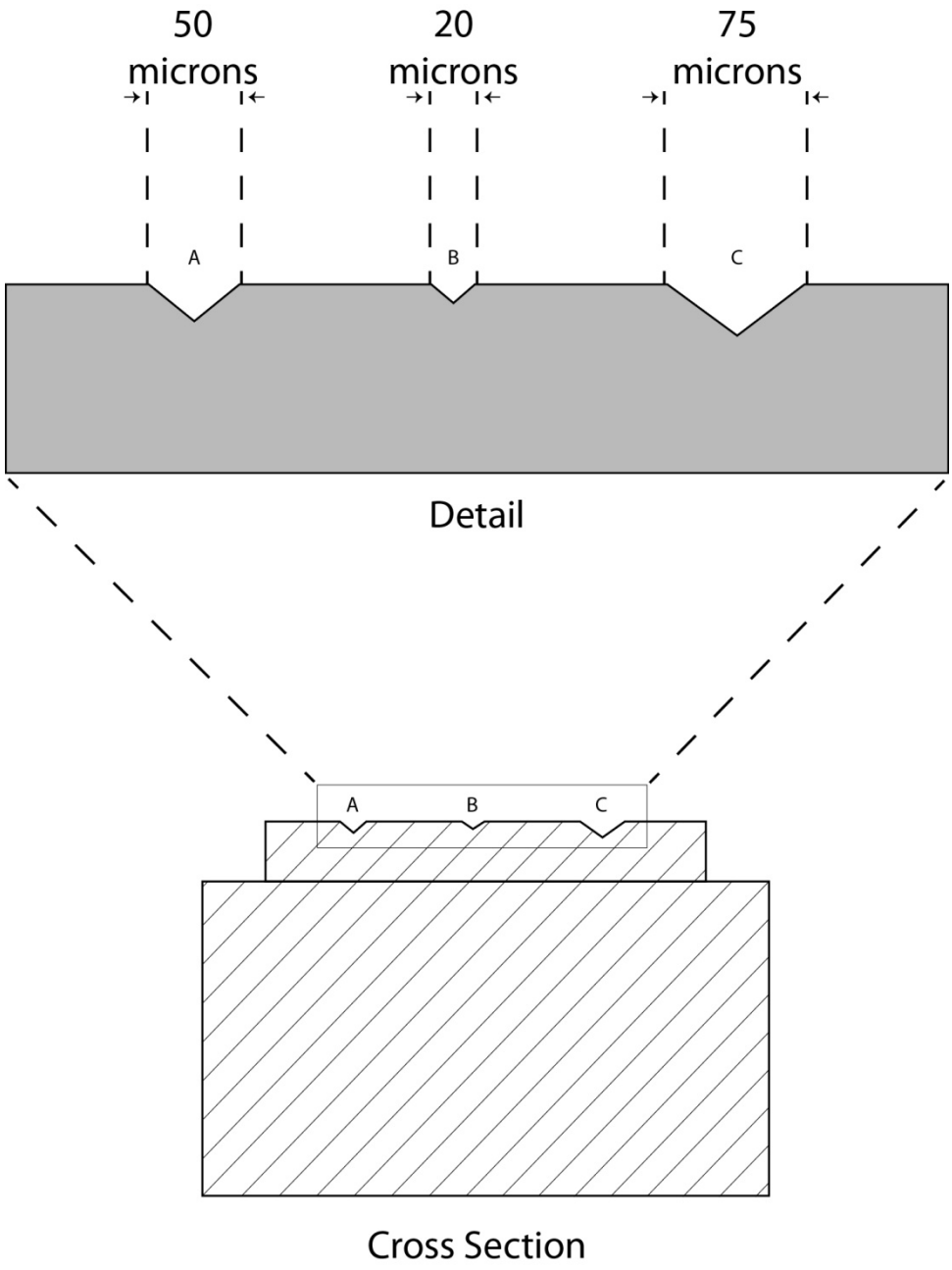


Figure 5: Schematic of the ANSI/ADA Specification No. 18 die surface from a lateral view.

Figure 6: Irreversible hydrocolloid impression test samples
From left to right:

A. Kromopan 100®
B. Identic®
C. Jeltrate Plus®

Figure 7: Gypsum test specimens
From left to right:

A. Die-keen Green®
B. Microstone Yellow®

CHAPTER FOUR

RESULTS

SPSS (version 2.0) was used to perform the statistical analysis. One-way ANOVA test was used to determine significance among group means. The least significant difference (LSD) test was applied for post-hoc comparisons.

Gypsum Compatibility

Among the tested impression materials and mixing techniques for gypsum compatibility, none of the combination groups met the required 66% requirement to pass for gypsum compatibility.

a) Kromopan 100®, 33% of the samples received a score of 1.

b) Identic™, 20% of the samples received a score of 1.

c) Jeltrate Plus®, none of samples received a score of 1.

d) Scores for gypsum compatibility with Kromopan 100® were higher than Identic® or Jeltrate Plus®. However, all three impression materials failed to meet the 66% requirement of the ANSI/ADA test parameter.

e) Vacuum-mixing, 28.3% received a score of 1.

f) Mechanical-mixing, 16.7% received a score of 1.

g) Manual-mixing, 13.3% received a score of 1.

h) Vacuum-mixing generated higher scores for the gypsum compatibility score for all impression materials tested than other mixing techniques.

Although there was no significant difference between impression materials mixed with a certain type of impression mixing technique. Overall, vacuum-mixed, Kromopan 100® demonstrated the best gypsum compatibility. Jeltrate Plus® impression material manually mixed consistently yielded the poorest compatibility with both types of gypsum materials.

Dimensional Stability

The linear dimensional change for each test specimen was calculated using y-coordinate and z-coordinate values obtained from the traveling microscope. The value represents the actual linear dimensional of each test cast specimen. In accordance with Specification No. 19, the percentage change in linear dimension is reported.

a) The mean linear dimensional change for Kromopan 100®, Identic™ and Jeltrate Plus® were 24.929mm, 24.886mm and 24.852mm, respectively.
b) The mean linear dimensional change for Vacuum-mixed, Mechanically-mixed, and Manually-mixed techniques were 24.926mm, 24.879mm, and 24.861mm, respectively.
c) Among the tested impression materials, there was significant difference in dimensional stability. ($P<0.001$)

   Kromopan 100® > Identic™ > Jeltrate Plus®

d) Among the tested impression mixing techniques, there was significant difference in dimensional stability. ($P<0.001$)

   Vacuum-mixing > Mechanical-mixing > Manual mixing

e) Among the tested impression material and mixing technique combinations, there no significant differences. (P >0.05)

Statistical Analysis

Post hoc comparisons using the LSD test showed that Kromopan100® impression material demonstrated better dimensional stability than Identic™ or Jeltrate Plus®. With regard to mixing techniques, the vacuum-mixing technique was showed statistically significant higher values for dimensional stability than the other mixing techniques. Although there was no significant difference between impression materials mixed with a certain type of impression mixing technique, Kromopan 100 impression material mixed with a vacuum mixing bowl, with Die-keen gypsum material yielded the best results.

Summary of Results

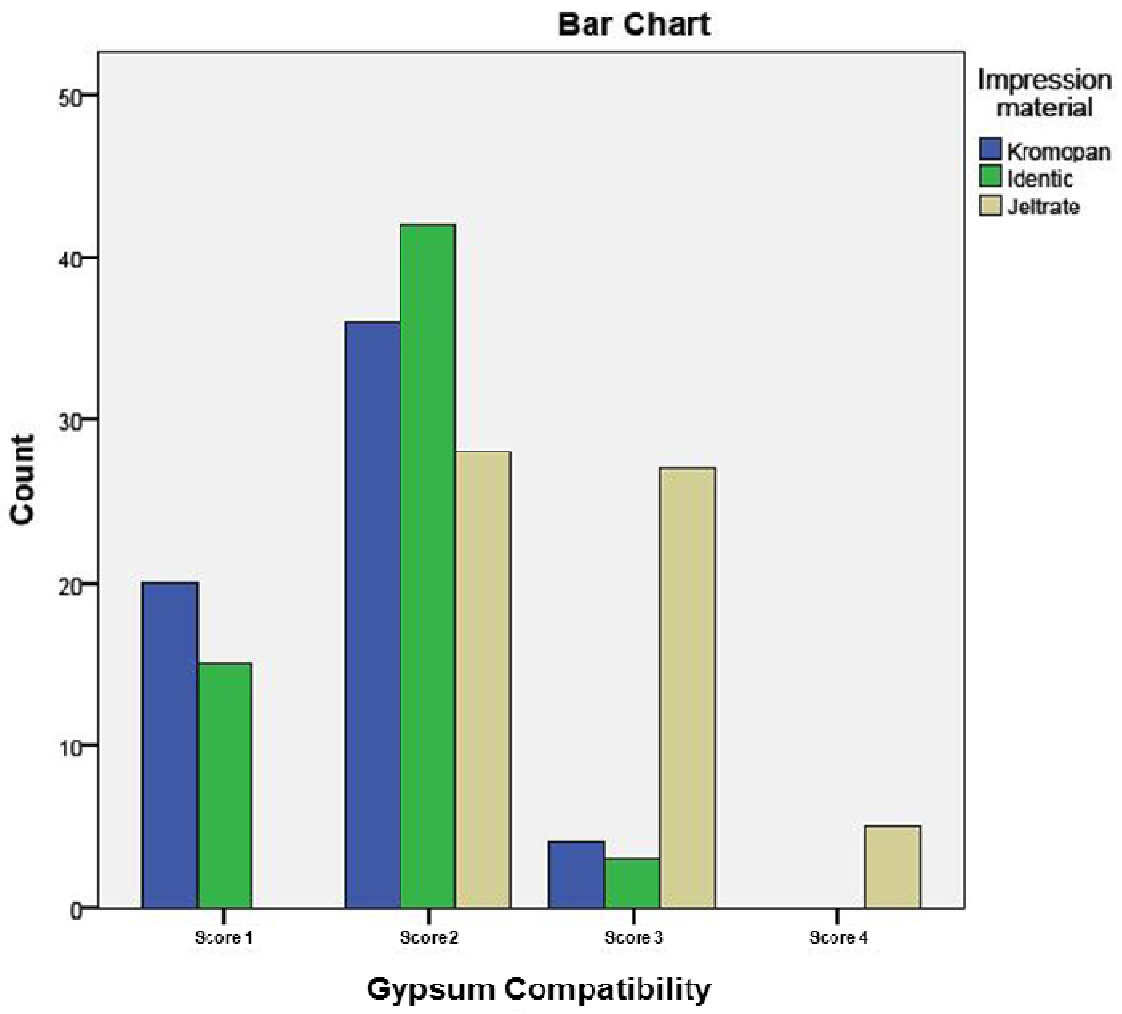
There was no statistical significance among the various combinations of impression materials and mixing techniques evaluated for dimensional stability (P >0.05) in this study.

For dimensional stability, the mean value for the vacuum-mixing technique (24.929mm) demonstrated better accuracy than the other mixing techniques. With regard to impression materials, Kromopan 100® (24.929mm) had better mean values than Identic or Jeltrate Plus.

All combinations of impression materials and mixing techniques failed to meet the 66% requirement to pass the Specification No. 18 requirement for gypsum

compatibility. Vacuum-mixed, Kromopan 100® and Die-keen® had the best results of the various mixing combinations with 6 out of 10 samples rated with a score of 1.

Based on the results, the null hypothesis was accepted for both gypsum compatibility and dimensional stability.



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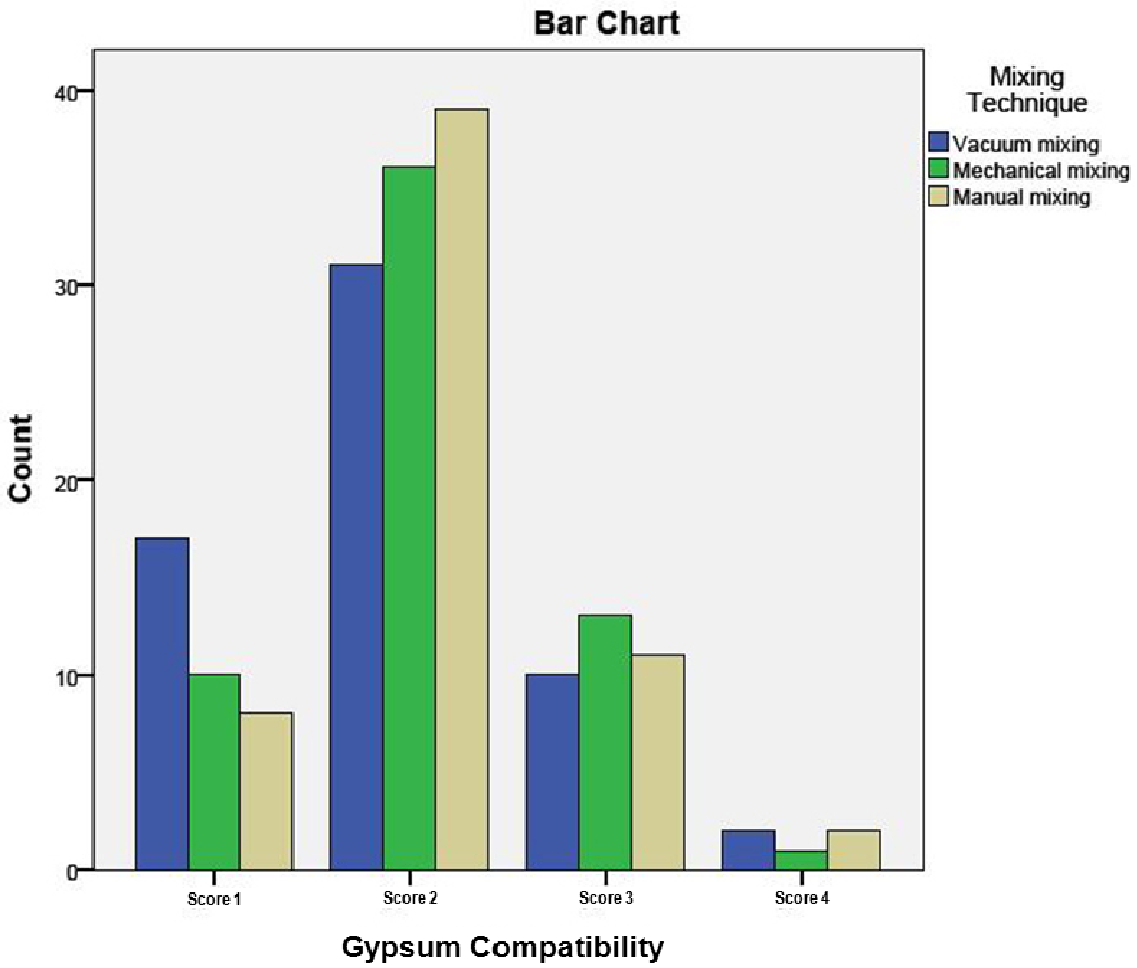
4	Line not reproduced over entire length, rough, blemished, pitted. This is the worst appearance.

Figure 8: Gypsum compatibility for impression materials



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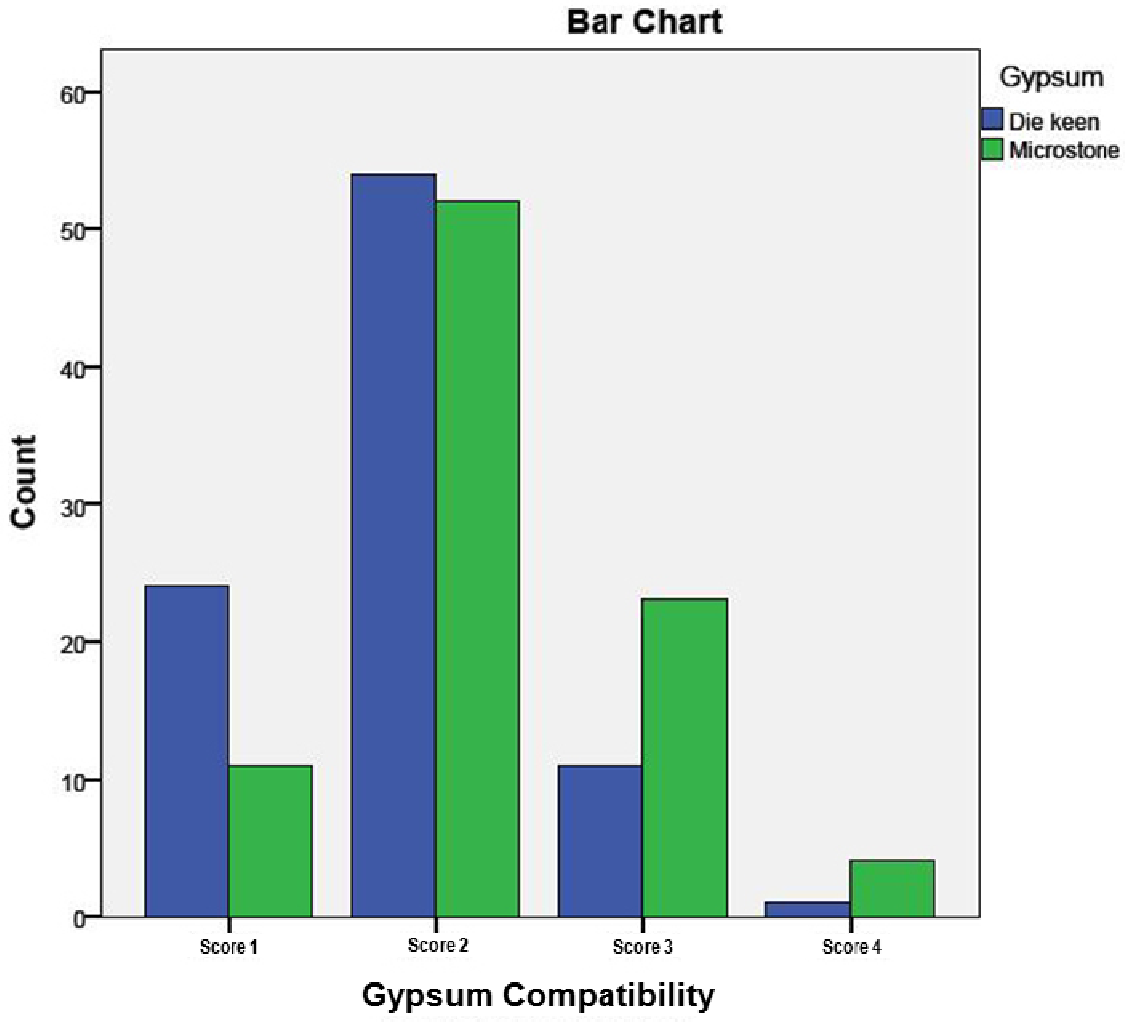
1	50 micron line reproduced clearly and sharply over the entire 25mm length. This is the best appearance.
2	Line clear over more than 50% of length, line appears to be reproduced well over the entire length, smooth, but not sharp.
3	Line clear over less than 50% of length, or line visible over the entire length but blemished and rough, and/or not sharp.
4	Line not reproduced over entire length, rough, blemished, pitted. This is the worst appearance.

Figure 9: Gypsum compatibility for different mixing techniques



Score	Description
1	50 micron line reproduced clearly and sharply over the entire 25mm length. This is the best appearance.
2	Line clear over more than 50% of length, line appears to be reproduced well over the entire length, smooth, but not sharp.
3	Line clear over less than 50% of length, or line visible over the entire length but blemished and rough, and/or not sharp.
4	Line not reproduced over entire length, rough, blemished, pitted. This is the worst appearance.

Figure 10: Gypsum compatibility for Microstone® and Die-keen®

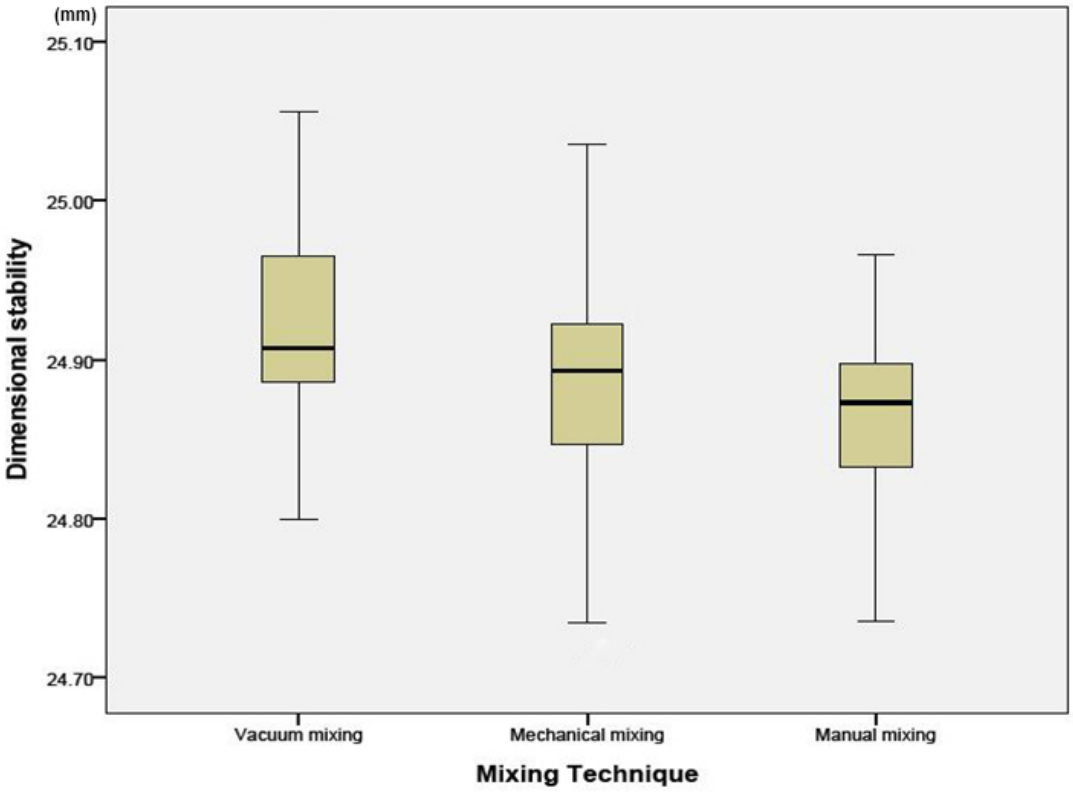


Figure 11: Box-plot values by dimensional stability

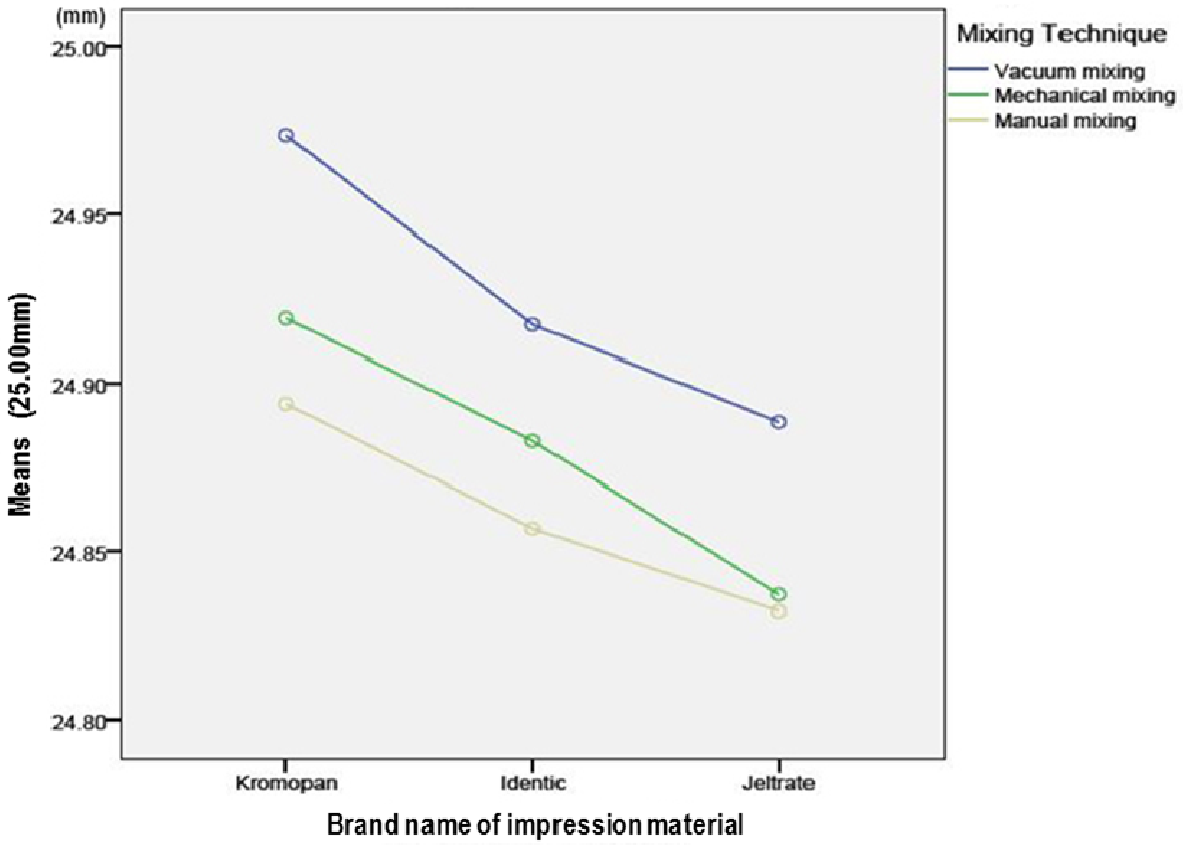


Figure 12: Dimensional stability values by impression material and mixing techniques

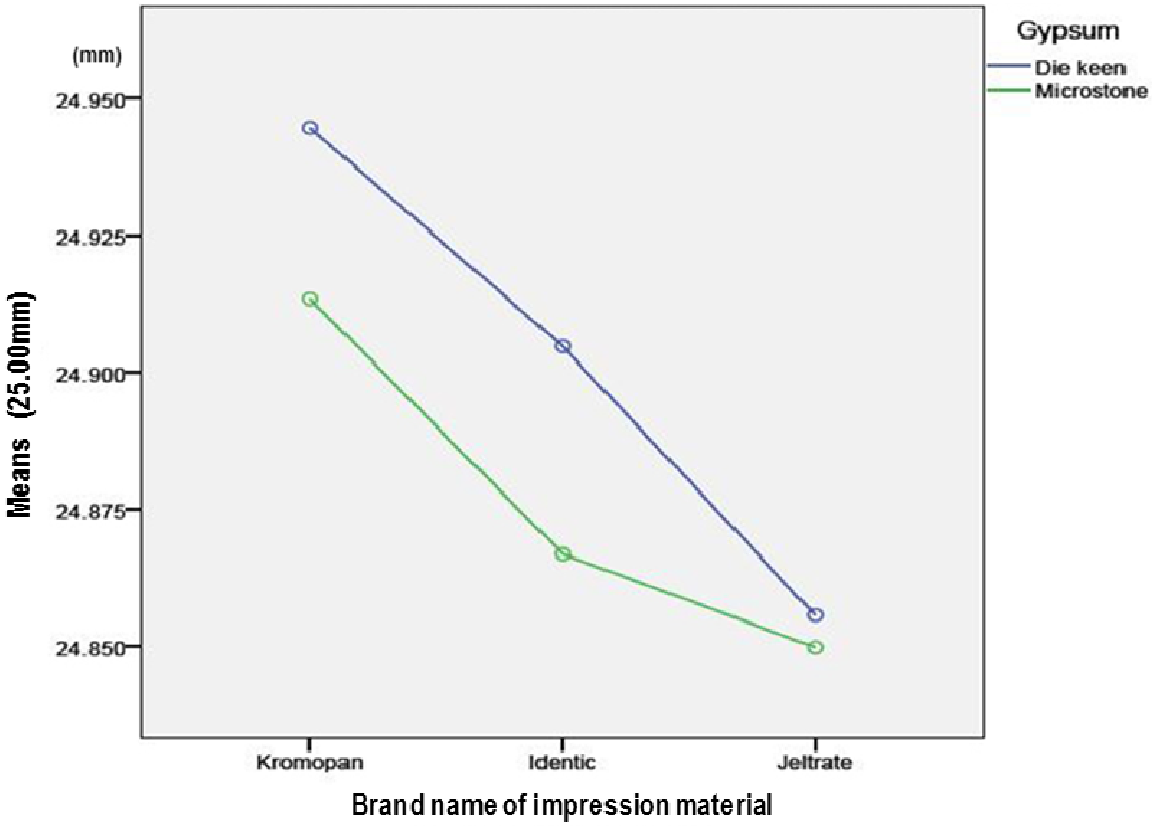


Figure 13: Dimensional stability values by impression and gypsum material

CHAPTER FIVE

DISCUSSION

In this study, irreversible hydrocolloid impression materials were subjected to different mixing techniques to demonstrate improvement over conventional manual-mixing techniques. The utilization of a mechanical or an automated mixing device has produced impression materials that have less porosity and improved mechanical strength[4, 5, 9]. The smooth surface texture of impression materials created by electronically operated devices produces a mixture that is easy to work with, better surface texture, improvement in rheological properties and produces accurate casts over the manual-mixed techniques[5, 15, 16].

Three brand name irreversible hydrocolloid impression materials were mixed with three different mixing techniques. Two gypsum materials were used to then fabricate test samples to compare and evaluate for gypsum compatibility of impression materials mixing with the different mixing techniques. In order to evaluate the effectiveness of different impression mixing techniques, gypsum compatibility and dimensional stability of gypsum casts reproduced from the impression materials were used to carry out this investigation.

Among the impression materials used in this study, Kromopan 100®, demonstrated better compatibility with both types of gypsum materials than the other impression materials. Although the impression/mixing technique combinations did not

show statistical significance for gypsum compatibility, there was a positive trend for gypsum compatibility with Kromopan® 100 than the other impression materials.

During the fabrication of the impression test specimens, there were a higher number of Jeltrate Plus® impression samples that were not able to duplicate the 20 micron line. Comparatively, a larger number of remakes were made of Jeltrate Plus® than the other impression materials. Vacuum-mixed and mechanically-mixed Kromopan 100 and Identic did not have any remakes. However, three samples each were remade for Kromopan 100 and Identic due to an air bubble superimposed over the 20 micron line. Of the 30 samples of Jeltrate Plus® impression material, 17 samples were remade. The manually-mixed technique had the highest number of remakes with 9 specimens. The inability of the impression material to reproduce the 20 micron line further supported the poor overall performance of Jeltrate Plus® impression material.

Among the two gypsum materials, in general, test specimens fabricated with Die-keen®, resulted in higher compatibility scores than Microstone®. These results are in agreement with previous studies[6, 17].

The test for dimensional stability was evaluated by using the formula:

$$\Delta l = 100(x_1\text{-}x_2) / x_1$$

x_1, measure distance on the ADA/ANSI master die

x_2, measure distance on the gypsum cast

Based on the results from this investigation, Kromopan 100®, Identic, and Jeltrate Plus exhibited a percentage decrease of 0.28%, 0.45% and 0.59%. These values are within the acceptable value of 1.0% for dimension change under ANSI/ADA Specification No. 19[18].

One of the goals for this study was to demonstrate if there is a significant difference between manual-mixing and electronically-mixed impression materials. However, due to the number of variables being studied, there was no statistical evidence to arrive at a conclusion that one mixing technique produced better impression materials for improved gypsum compatibility and dimensional stability than the other. The vacuum-mixing technique does produce a smooth, uniformly mixed, bubble-free impression[5, 16]. But the statistics was not able to distinguish which combination of impression material/mixing technique produced the gypsum compatibility and dimensional stability.

CHAPTER SIX

CONCLUSIONS

Gypsum compatibility and dimensional stability were evaluated for three brand name irreversible hydrocolloid impression materials, (Kromopan 100, Identic, Jeltrate Plus) mixed manually with a rubber mixing bowl and a spatula, mechanically with a rotary mixing device and under vacuum with a vacuum-mixing bowl. 10 samples of 9 different impression material/mixing technique combinations were evaluated with two gypsum materials. In total, 90 Die-keen and 90 Microstone casts were fabricated to evaluate gypsum compatibility and dimensional stability. Within the limitation of this investigation, the following conclusions can be drawn:

1. For evaluation of gypsum compatibility and dimensional stability, Kromopan 100® was the most accurate compared to the other tested impression materials.
2. Impression materials mixed under vacuum produced better compatibility for gypsum and less dimensional change.
3. Die-keen gypsum material produced the more accurate casts for all alginate materials studied.

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