University of Benghazi

Faculty of Dentistry

Department of Prosthodontics

Evaluation the effect of thickness on tear strength of some types of alginate impression and compare their dimensional accuracy with addition silicone after repeated pouring.

(In vitro study)

By

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Declaration

I declare that this study is an individual work in which there was no unethical behavior during all the stages from planning the thesis until its writing and all the information in this thesis was obtained according to academic and ethical rules. I declare that I have referenced all the interpretations not obtained in this study and that these sources are listed in the list of sources, there is no violation samples or working during this study and the writing of thesis.

Dedication

This work is dedicated to…

My lovely family, for their endless love and support.

My mother and brothers and my husband, for their encouragement and motivation to fight and face all obstacles.

My wonderful friends for their support and help.

Acknowledgment

First of all, all praise is due to **Allah**, the most beneficent and the most merciful for the blessings, guidance and generosity he bestowed on me throughout my life.

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List of Abbreviation

Abbreviation	Term
P/W	Powder to water
KN/m	Kilonewton per millimeter
mm	millimeter
ISO	International standard organization
µm	micrometer
ANSI	American national standard institute
ADA	American Dental Association
PVS	Polyvinylsiloxane
Wt	Wight
min	minute
N/mm	Newton per millimeter
Ibf/in	Pound force per inch
Kgf/cm	Kilogram force per centimeter

Abstract

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By

Najla H. Abd alraheem
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Abstract

Alginate impression material is widely used in dentistry due to its low cost and ease of use. However, the disadvantage of hydrocolloid impression materials is their dimensional change and low tear strength. The aim of this study was to evaluate the dimensional stability of the dental cast obtained from the alginate, addition silicone impression of the acrylic model after repeated pouring, and the dimensional stability of the alginate impression after different storage times(1/8 day, 3days, 5days and 9days). The tear strength of alginate impression materials of different thicknesses was also evaluated (2mm, 3mm and 4mm).Regarding the dimensional stability, the analysis showed that repeated pouring of impression materials had no statistically significant effect on dimensional stability where $p > 0.05$, with the exception of the conventional type. Also, the analysis showed there was no significant difference in dimensional accuracy of the casts poured after 5 days of alginmex impression, Also there was no significant difference in dimensional accuracy of the casts poured after 9 days of cavex impression materials, where the p-value > 0.05. While there was a significant difference in dimensional accuracy of the casts poured after 9 days of alginmex impression. In tear strength analysis, there was no significant difference in tear strength between three different thicknesses of alginate impression materials, Where the p-value was (0.611,0.969, 0.516) for alginmax, cavex, and conventional materials respectively. Conclusion: clinically acceptable casts can be obtained by the double pour of new-generation alginate materials. The dimensional stability of alginate impressions was directly influenced by the type of alginate and the time of poured the impressions after the different storage times. Alginmax could be poured after 5 days and Cavex impression could be poured after 9 days of storage with no significant dimensional changes. There is no difference in tear strength between the three different thicknesses of each type of alginate impression material.

Introduction

1.Introduction:

The Dental impression material plays an important role in dentistry because it reproduces negative replicas of intraoral conditions.

Impression materials are classified as elastic and non-elastic materials. Elastic materials include hydrocolloid and elastomeric impression materials. Hydrocolloid impression material can be either reversible or irreversible.(Ocarina, Raharja,2018)

Alginate is classified as a hydrocolloid impression material because after reacting with water, the alginate will form a sol. It is also an irreversible material since it cannot change back to its former shape after interaction with water. Alginate's active component is either sodium or potassium. The sodium alginate will further form a solid gel which needs to be thick to obtain an excellent alginate impression.(Ocarina, Raharja,2018)

Alginate impression material was originally developed in the 1930s and has been used in dentistry for over 50 years. During World War II, due to a shortage of raw materials for reversible hydrocolloids, irreversible hydrocolloids were introduced and their use subsequently exploded. Today the alginate is the most commonly used impression material in the world.

It is popular because the material is easy to manipulate, fairly comfortable to the patient, and relatively inexpensive for the dentist.(Frey et al.,2005)

This type of impression material is used for many purposes such as preparation of a study cast for diagnosis, fabrication of provisional prosthesis, custom trays, appliances and a definitive cast for fabrication of complete dentures in cases with undercut areas, partial denture and for maxillofacial prostheses.(Rohanian et al.,2014)

It is very important that alginate has enough strength in order to do not tear upon removal from mouth. Factors that contribute in alginate gel strength such as:

Powder/Water ratio, mixing time, time of removal from mouth, and rate of removal from mouth. Clinically, the initial set of alginate is determined by a loss of surface tackiness. An alginate impression should be left in the mouth for an additional 2 to 3 minutes after the initial set to permit the development of additional strength.(Fayaz, Noori,2016) Tearing in the impression causes defects, which affect the accuracy of the final restoration. (Lawson et al.,2008)

For alginates, tear strengths vary from 0.4 to 0.7 KN/m, and this property is probably more important than the compressive strength.(Ronald, Sakaguchi ,2012) The tear strength is important when an impression involves a mechanical undercut and/or lacks bulk strength to resist tearing.(Cohen et al.,1998)

Making an impression represents a critical step in processing and fitting of a dental prosthesis. The definite impression should be accurate to fabricate restoration with ideal marginal fit, internal fit, interproximal contacts and occlusal contacts.(Nam et al.,2007; Mishra , Chowdhary ,2010)

The impression materials are used to register or reproduce the form and relations of the teeth and the surrounding oral tissues. Dimensional accuracy and stability are the primary requisites of an impression material. Accuracy of an impression depends on properties of impression materials like thermal contraction, polymerization shrinkage, presence of volatile by products, elastic recovery, bulk of material and impression technique used.(Mehta et al.,2014) Other factors which influence the accuracy of an impression are tray material, space between tray and tooth preparation, storage conditions, relaxation of stresses caused by the use of non-rigid trays, excessive seating pressure, too slow removal from the mouth or an impression removed before the polymerization is complete .

A variety of impression materials as silicones, polyether, polysulfide and alginate are available for crowns and fixed partial denture impressions. The addition-type silicone impression material i.e. polyvinyl siloxane is the most preferred material in the field of prosthodontics due to its favorable qualities, relative simplicity and reliability. Polyvinyl siloxane impression materials are reported to have precise detail reproduction, dimensional accuracy and stability, low creep, a relatively short setting time, moderate to high tear resistance and elastic recovery from undercuts.(Mehta et al.,2014)

The accuracy of an impression with repeated pour is of great advantage for the clinician and laboratory technicians. It reduces the professional clinical time, patient inconvenience and extra material cost.(Haralur et al.,2016)

Stone dies poured successively from the same elastomeric impressions became increasingly shorter in length and thicker in diameter . However Tjan et al. found that the repouring and delayed pouring of the rubber base impressions did not affect their dimensional accuracy and stability.(Mehta et al.,2014)

Ali et al (2010) concluded that repouring of the impression up to seven days did not affect the dimensional accuracy of the resultant casts.(Ali et al.,2010) Most of the times dentist wants to have two or more casts out of the same impressions, to avoid the problems associated with repeated impression making. Obtaining multiple accurate casts from the single dental impression is advantageous in generating duplicate dies, assembling multiple individual cast restorations on an intact cast, replicating the abutment gingival relationship, and enhancing the edentulous ridge anatomical architecture.(Pritam, Mall,2020)

The current study was conducted to evaluate the tear strength and dimensional accuracy of three types of alginate impression materials compared with addition silicone impression materials after repouring the impression and then evaluated the resultant casts.

Review of literature

2. literature review:

The Impression materials are used to make an accurate replica or mold of the hard and soft oral tissues. The area involved may vary from a single tooth to the whole dentition, or an impression may be made of an edentulous mouth. The impression is a negative reproduction of the tissues, and by filling the impression with dental stone or other model material, a positive cast is made that can be removed after the model material has set .(craig ,2012)

Usually, the impression material is carried to the mouth in an unset (plastic) condition in a tray and applied to the region under treatment. When the impression material has been set, it is eliminated from the mouth with the tray. The cast is made by filling the impression with dental stone or a different model of the material. The accuracy, detail, and quality of this final duplicate are of the greatest importance. (Craig ,2012)

The cast, and therefore the impression, must fulfill certain criteria (as laid down in International Standards ISO 1563: 1990E and ISO 4823:1992E) including both accuracy and dimensional stability, if it is to be a useful representation of the oral structures.(Gupta,Brizuela, 2021)

The fabrication of an excellent prosthesis starts with making a good impression Fabricating an exactly fitting prosthesis completely depends on a correct impression making. (Rubel ,2007)

The art and science of impression making was first described in 1755 when Philip Phaff proposed an impression technique using softened wax.(Pitel ,2005)

Wax was the only impression material utilized in dentistry till the mid-nineteenth century when gutta-percha first appeared. Then in 1857, Charles Stent created a thermoplastic modeling compound just like the modern impression compound. Still, the trouble with this material become that it become rigid and couldn't reproduce undercut areas.

All the impression materials used till that date have become inflexible after setting and couldn't replica the oral tissues accurately. Thus, there has been always wanted for an impression material that might stay elastic even after setting. That is while agar, a reversible hydrocolloid product of algae, become introduced in dentistry.(Gupta,Brizuela, 2021)

In the 1930s, hydrocolloid materials (agar and alginate) appeared..(Heisler et al,1991;Wassell et al., 2002) When the algae used to manufacture agar was unavailable during the second world war, Americans used local algae to manufacture another elastic impression material known as alginate, which has gained popularity since then (Gupta,Brizuela, 2021)

In the 1950s the rubber base materials, first in the form of the polysulfide and later the silicone, began to be used as dental impression materials. (Craig ,1997)

2.1. The critical properties for impression materials :

- should have pleasant odor, taste, and color.
- absence of toxic or irritant constituents.
- economically commensurate with the obtained results.
- easy to use with the minimum of equipment.
- suitable working and setting time.
- adequate shelf life of storage and distribution.
- should be elastic to allow the removal from the undercuts without permanent deformation.
- adequate strength so it will not break or tear during removal from the mouth.
- should give accurate reproduction of tissue details.
- should be compatible with cast and die materials.
- should be viscous enough to be contained in the tray that is seated in the mouth.
- should be fluid enough to adapt to the soft and hard oral tissues.
- can be disinfected without any change of properties. (Terry et al.,n.d)

2.2. Classification of impression materials

Impression materials are classified according to their elastic properties once set and are broadly divided into non-elastic and elastic materials (Figure 2.1)

Non-elastic impression materials are generally not used for obtaining impressions of crown preparations because of their inability to accurately record undercuts. The elastic impression materials are further divided into two groups: the hydrocolloids and elastomers.

The hydrocolloids are further divided into the reversible hydrocolloids (Agar-agar) and the irreversible hydrocolloids (Alginate) while elastomers are further divided into polysulphides, polyether, condensation silicones and addition silicones.(Wassell et al., 2002;Kenneth,2013)

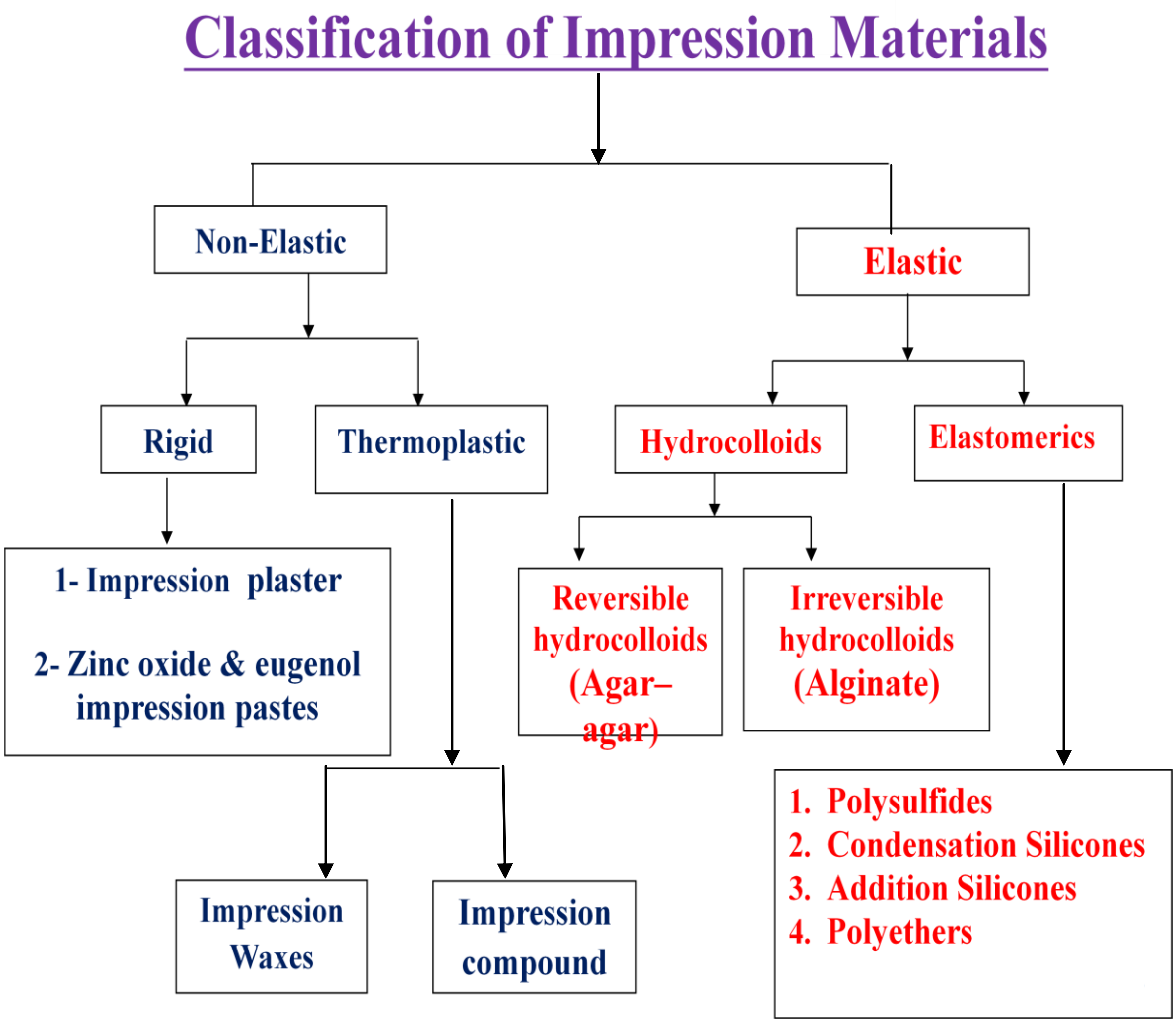

Figure 2.1:Classification of impression materials.

2.3. Hydrocolloid impression materials

A colloidal system consists of two phases; the dispersed phase and the dispersion phase. If the dispersion phase of the colloidal system is water, it is called hydrocolloid. Hydrocolloid impression materials are based on the colloidal suspension of polysaccharide in water.

In sol form: there is random arrangement of polysaccharide chain. In gel form: the long polysaccharide chains become aligned and material becomes viscous and develops elastic properties.(Madhavan , 2015)

Based on the mode of gelation, they are classified as: reversible hydrocolloids e.g. agar, irreversible hydrocolloids e.g. alginate. (Madhavan ,2015)

2.3.1. Reversible hydrocolloid impression materials(agar-agar)

Reversible hydrocolloid was introduced to the dental career in 1925 by Alphons Poller, an Austrian as impression.(Askar,1971)

Agar was first introduced into dentistry for recording crown impressions in 1937 by Sears and was the first elastic impression material available. (Arqoub et al., 2018) It is a natural hydrophilic colloid extracted from certain sorts of seaweed.(Madhavan ,2015)

The use of agar agar was now no longer handy because it required special devices including heaters, syringes, and water-cooled rim lock trays. Agar agar impression materials are now no longer utilized in clinics due to the inconvenience of manipulation, while alginates are still popularly advocated . Alginates stay as an economical alternative and easily manipulated impression material .(Arqoub et al.,2018)

2.3.2.Irreversible hydrocolloid impression materials (alginate).

2.3.2.1. History:

Algin was discovered in 1881 by an English chemist, E. C. C. Standford. This chemist had found that a gelatinous precipitate was obtained if a mineral acid was added. The precipitate was identified as a new acid, and he named it as “alginic acid.” He then carried out further investigation to determine the uses of this product.(Kaur et al .,2012)

Alginate impression material was originally developed in the 1930s and has been utilized in dentistry for over 50 years. During World War II, because of a shortage of raw materials for reversible hydrocolloids, irreversible hydrocolloids were introduced, and their use eventually exploded.(Doubleday,1998) Alginate impression materials are one of the most widely used materials in dental clinics . Alginates are the salts of alginic acid, which is a polysaccharide derived from marine algae . Potassium or sodium alginates are used in the dental field as they are water soluble and react with calcium ions, forming an insoluble calcium alginate gel.(Abdelraouf et al., 2021)

This type of impression material is used for many purposes such as preparation of a study cast for diagnosis, fabrication of provisional prosthesis, custom trays, appliances and a definitive cast for fabrication of complete dentures in cases with undercut areas, partial denture and for maxillofacial prostheses.(Rohanian et al.,2014)

2.3.2.2. Composition and setting reactions

Alginate impression materials consist of a powder that when mixed with water forms a fast-setting gel. The reactive constituents of alginates are sodium or potassium salts of alginic acid and calcium sulfate that when mixed with water form a sol.(Imbery et al.,2010)

Alginate impression consist of Potassium or sodium alginate 15% Calcium sulphate 16% Zinc oxide 4% Diatomaceous earth 60% Potassium titanium fluoride 3% Sodium phosphate 2%).(Madhavan ,2015) Fillers such as diatomaceous earth are added to the dental alginate to strengthen the gel. The standard composition of alginate is as describe in Table2.1.(onwubu,stellamaris,2020) Once mixed, the alginate turns into a soft paste that is placed on the tray and introduced into the oral cavity for the detection of the impression.(Cervino et al.,2018)

Once the dental alginate powder is blended with water, the alginate is changed into a smooth paste (sol) this is transformed to a gel through chemical reactions: the first is a retardation reaction, giving time for the alginate to be manipulated and inserted into the patient’s mouth, and the second one is a gelation reaction. (Abdelraouf et al., 2021)

In the retardation reaction, a retarder (sodium phosphate) reacts preferentially with a reactor (calcium sulfate) to provide working time before gelation . The second reaction is gelation, where the soluble salts of alginic acid (potassium or sodium alginate) react with the calcium ions released from the reactor, forming an insoluble calcium alginate gel.(Abdelraouf et al., 2021)

Table 2.1. The composition of alginate impression.

Material	**Percentage (Approximate)**	**Purpose**
Sodium or potassium alginate	15–20%	Colloidal particles as basis of the gel
Calcium sulphate dihydrate	14–20%	Creates irreversible gel with alginate
Potassium sulphate	10%	Ensures set of gypsum materials
Trisodium phosphate	2%	Retarder to control setting time
Diatomaceous earth	55–60%	Filler to increase thickness and strength
Other additives: chemical indicators	Very small quantities	Color change
• Organic glycols • Flavoring agents • Coloring agents • Disinfectants		Reduce dust when powder is handled Improve taste of material Provide pleasant colors Cause antibacterial action

The chemical reaction occurs in two phases: a first phase called ‘slowing’ and a second phase called ‘setting’. Initially the powder is blended with water and the sodium phosphate reacts with the calcium sulfate to permit an adequate processing time. After the sodium phosphate has reacted, the remaining calcium sulfate reacts with sodium alginate to form an insoluble calcium alginate that forms a gel with water which acts as a catalyst.

The alginates available on the market can be of two types (Cervino et al.,2018)

- Type1- fast setting (hardening time of 1–2 min)
- Type2- normal setting (setting time between 2–5 min).

The setting time depends on the composition (water/powder ratio, where increasing the powder accelerates the hardening reaction) and the temperature at which mixing takes place (the setting time is inversely proportional to the temperature, where the higher the temperature, the lower the setting time and therefore the reaction is faster). Dust tends to lose its organoleptic characteristics when exposed to moisture or heat. To obtain a better product, the alginate must be integrated with the following:

1. Borax, zinc sulphate, and sodium fluoride in order to increase the resistance of the impression and the hardness of the model surface, avoiding the adherence of the impression of alginate to the plaster during the casting of the model.
2. Fossil flour or diatomaceous earth, which has the function of being a filler and also controls the fluidity and the consistency of the mass, making the impression surface smooth and compact.
3. Chemical indicators: These are substances that have the ability to make the material change color as its acidity varies during the gelling reaction .(Cervino et al.,2018)[31]

2.3.2.3. Mixing and loading the tray:

Commonly used alginate materials are provided in containers. A scoop is supplied for measuring the powder; and a cylindrical plastic measuring cylinder, for measuring the water volume.

Mixing is initiated by adding a measured amount of water to a clean flexible rubber bowl and this is observed by the addition of correctly proportioned powder. A longer working time is obtained by using cold water ,setting time has to be managed with the aid of using various water temperatures, and not the consistency of the mix.

The mixing has to be fast with a wide-bladed spatula, and the resultant blend has to be creamy in consistency but must not drip off the spatula when lifted from the bowl. Mechanical mixing of alginate in devices such as the Alginator II (Dux Dental, Oxnard, California) or the combination unit (Whip Mix, Louisville, Ky) ensures that the alginate mix is the same each time they are mixed. Mixing time is 60 seconds for hand spatulation and 15 seconds for mechanical.

The required amount of material is loaded onto the tray which must be filled with the impression material up to the tray borders and any excess unsupported material (over-filled tray) at the periphery must be removed with the mixing spatula and the surface of the alginate is smoothed with a wet gloved finger.(ashely et al.,2005)

2.3.2.4. Impression making:

Impression tray is positioned within the mouth by retracting the patient' lips on one side with a mouth mirror/gloved finger; and on the opposite side by rotating the tray into the mouth.

The tray must be centered in position in the mouth; and with light-weight pressure, impression is held in place. The soft tissues, particularly labial flange, should be relieved and manipulated for the alginate to flow into the sulci and record the details and once tray is seated, pressure should be released immediately and also the tray should be held gently in place to prevent unseating.

Once set, the impression has to be removed with a firm, quick snap. The impression mustn't be rocked or twisted before or throughout removal of the impression and this can be to reduce the time that the set material is distorted as it moves over the teeth. (Nandini et al .,2008)

Set alginate undergoes imbibitions and syneresis if left in a normal clinical environment and after being removed from the mouth, alginate impressions should be washed with a water spray, disinfected by means of the practitioner's choice of disinfection procedures, and dried until the shine just disappears. The impression has to be covered with damp gauze and left in a zip-lock plastic bag until the cast is poured . The time before cast-pouring is critical. (ashely et al.,2005)

Patients can tolerate alginate more easily than other impression materials because it quickly becomes solid and has a fresh aroma and taste, thus decreasing the gag reflex in patients.(Mitchell ,2005)

It has a low wetting angle and hence full arch impressions are easily captured. (Craig ,Robert ,2002) Impressions made with irreversible hydrocolloids are easier to remove than those with elastomeric materials. As their tear strength is low, they can reproduce sub gingival contours and anatomy but tear upon removal.(Craig ,Robert ,2002) They are good for only one pour per impression.(Donovan, Chee, 2004)

Compared to other impression materials, irreversible hydrocolloids have the disadvantages of low dimensional stability and reduced capacity for detail reproduction. (Rodrigues et al.,2012)

Dental casts obtained from impressions made with irreversible hydrocolloids tend to present decreased detail reproduction, particularly in sharp line-angle areas, compared to those from other impression materials, such as elastomers.(Rodrigues et al.,2012)

The greatest disadvantage of irreversible hydrocolloids is their low dimensional stability. Water absorption (imbibition) and water exudation (syneresis) that happens over time may lead to the production of inaccurate casts, and it's usually suggested that irreversible hydrocolloid impressions should be poured directly or within few minutes once removal from the mouth.(Kusugal et al .,2018)

Distortion are often a problem if disinfection guidelines are not strictly followed. Because hydrocolloids are hydrophilic, they swell if immersed in water or disinfectant for long time.(Phoenix et al.,2002; Miller ,1975)

2.3.3.Disinfection:

Dental specialists are exposed to a wide kind of microorganisms in the blood and saliva of patients. These microorganisms cause infectious illnesses such as the common cold, tuberculosis, pneumonia, hepatitis B, herpes and acquired immune deficiency syndrome (AIDS).

The use of effective contamination control processes within the dental workplace could protect dentists, dental workplace staff, dental technicians, and patients.(ADA Council on Scientific Affairs and ADA Council on Dental Practice, 1996)

There are two common methods to disinfect dental materials: (1) immersion and (2) spraying. Disinfection by soaking in chemical materials has been shown to cover all surfaces of impression materials in one time, while spraying is not capable of disinfecting all surfaces effectively and also cannot cover all undercuts. Contrary to immersing, spraying can significantly reduce the amount of distortion. Some impression materials, like alginate which is commonly used in dentistry, absorb water and distort when they are immersed in disinfectant materials due to their hydrophilic properties.(Al-Jabrah et al.,2007 ; Ghahramanloo et al.,2009)

Alginates could hold more microorganisms than other impression materials as stated by previous study.(Al-Jabrah et al.,2007)

According to Ahsana M.R (2019) ,1% sodium hypochlorite and 2% glutaraldehyde significantly reduced microbial count from alginate impression surface. Among them 2% glutaraldehyde showed more antimicrobial effect than 1% sodium hypochlorite. He also concluded rate of bacterial transmission from alginate impression to cast was significantly reduced in case of 1% sodium hypochlorite solution than 2% glutaraldehyde solution.(Khadeer et al.,2019)

The Irreversible hydrocolloid Sprayed with sodium hypochlorite, rinse, spray again and stand under damp gauze or in sealed bag for 10minutes or Immersed in 2% glutaraldehyde for 10 minutes.(Sumanth et al., 2019)

2.3.4. Evolutionary changes in the alginate impression material

Alginate is extensively used because of its low method sensitivity, hydrophilicity, ease of manipulation, fine taste and odor, low cost, long shelf life, and compatibility with cast material. (Al Qahtani et al.,2019)

Though these types of advantages, it has a few disadvantages like dimensional change, poor tear energy, and the presence of dust in alginate powder which has poisonous potential. Therefore, widespread efforts were made in developing and enhancing alginate properties and decreasing its flaws. And that is a number of them:

2.3.5. The modification of alginate impression materials

2.3.5.1. Dustless alginates

These materials had been developed to eliminate silicosis, that's resulting from the presence of diatomaceous earth in the form of fillers in traditional alginate impression materials.

These filler are low-density siliceous fibers with dimensions of 3-20 μm and greater capacity carcinogens. These fibers will increase in the form of dust during utilization and inhalation of these fibers may cause respiration problems. (Alla,2013)

For those reasons, an attempt become made to increase the density of siliceous fibers via way of means of coating them with dedusting agents like glycerin, glycol, polyethylene glycol, and polypropylene glycol.(Alla,2013 ;Srivastava et al .,2012) Numerous producers additionally incorporated tetrafluoroethylene to keep away from the dust debris raising by forming the cobweb during mixing. (Kaur et al.,2012)

Recently, sepiolite (natural mineral fiber-containing magnesium silicate -20%) was added to the alginate materials that enable keeping alginate particles collectively to prevent the leaping of dust debris, and this decreased the dust generation from alginate impression materials during dispensation.(Kaur et al.,2012; Alaghari et al.,2019)

2.3.5.2. Alginate in the form of two-paste system

Alginates have been developed in two-paste systems to prevent the contamination of powder, and inconsistency in dispensing a certain amount of powder. It includes base paste and catalyst paste. The base paste consists of soluble alginate, water, and fillers, while the catalyst paste consists of calcium salts, viscous liquids like liquid paraffin, and magnesium hydroxide as a pH stabilizer. (Alaghari et al., 2019)

2.3.5.3. Chromatic alginates (alginates with color indicators)

Various color indicators had been introduced to the alginate impression substances to discover the different stages of manipulation. These color signs change the color of the alginate mix as the setting reaction takes place because of the change in the pH.(Srivastava et al.,2012)

These are upgrades will facilitate and assist the nurses and college students in identifying the proper consistency of alginate material to load it into the tray and make correct impressions.

2.3.5.4. Extended pour alginate

A set alginate impression contains approximately 70% of water. Due to its high water content, moisture will be lost from the alginate causing undesirable macroscopic shrinkage and distortion of the impression if it is left exposed to air at room temperature.(Nandini et al.,2008)

Researchers, in the past, have advocated immediate pouring of a gypsum product into the impression due to the fact there has been no adequate storage technique for any hydrocolloid impression material. According to Morrow et al, the maximum common mistake made in the usage of alginate impression materials was not pouring the gypsum product into the impression immediately. (Morrow et al.,1980) Cohen et al. measured the dimensional accuracy of three distinct alginate impression materials below different storage situations and discovered that the immediate pouring technique produced greater correct casts. (Cohen et al., 1995)

Therefore, the manufacturers' attempts to deal with this trouble have led to the improvement of new alginate materials that may be preserved for approximately a hundred hrs. and as much as four weeks. (Rohanian et al.,2014; Imbery et al.,2010)

Torassian et al reported that 2 irreversible hydrocolloid alternative materials, AlgiNot FS and Position Penta Quick, were dimensionally stable over an extended period (up to 7 days).(Torassian et al.,2010)

Another study showed that 3 irreversible hydrocolloid alternative materials, AlgiNot, Position Penta Quick and Silgimix, underwent dimensional changes that were within the acceptable linear dimensional changes defined by American National Standards Institute/American Dental Association (ANSI/ADA) Specification 19.(Patel et al.,2010) However, the measurements in that study were made directly from the impressions, rather than from casts poured using the impressions.

Imbery et al. compared a traditional alginate and with these new generation alginates and concluded that the newer generation alginates produced accurate casts at 5 days (120 h) when stored properly.(Imbery et al.,2010) Nehring and Imbrey in another similar study quoted that casts obtained after double pouring of a new generation extended pour alginate were accurate. (Nehring et al .,2018)

Another study performed by Haywood and Powe recommended that after alginate impressions are stored in wet condition by completely wrapping in a humid paper towel during stone setting and poured within 45 min, diagnostic casts may be generated from one impression with an identical degree of accuracy. (Haywood et al.,1998)

It is generally advocated that irreversible hydrocolloid impressions be poured immediately or within 10-12 mins of elimination from the mouth without wrapping in a humid paper towel.(Donovan , Chee ,2004; Sedda et al.,2008) This is as it is not possible to are expecting the quantity of water that can be absorbed by the impression material. However, immediate pouring of an impression may not always be possible, particularly if it must be shipped to a dental laboratory. (Gu¨mu¨s et al.,2014)

Imbery et al (2010) they study the accuracy and dimensional stability of extended pour and traditional alginate impression materials and before storage, the operator wrapped the traditional alginate impressions in damp paper towels by the use of 12 milliliters of tap water per towel to simulate the protocol taught at their institution. Following the manufacturer's instructions, they did not wrap the extended-pour alginate impressions in paper towels but simply sealed them in plastic zipper storage bags. (Imbery et al., 2010)

Currently, available irreversible hydrocolloid alternative products are provided as medium-body addition-type polyvinyl siloxane (PVS)–based materials. According to the manufacturers of products such as AlgiNot FS and Position Penta Quick ,the pouring of impressions can be delayed without any adverse outcomes at the final result.

The manufacturers also claim that impressions can be used for repouring casts. (Nassar et al.,2010) The term "alginate substitute" became first utilized in 2 research published in the 1980s.(Eames ,Litvak ,1984)

2.3.5.5. Self-disinfected alginate

Mantena, SR et al. (2019) reviewed numerous techniques employed to disinfect dental impressions. It become suggested in the literature that the traditional disinfection techniques which include immersion and spraying techniques which may cause undesirable dimensional changes within side the alginate impression as they were hydrophilic.

Several researchers developed alginate impression materials by incorporating disinfectant agents of their compositions. The disinfectant materials incorporated include chlorhexidine, quaternary ammonium compounds, didecyd-imethy ammonium chloride, and bisquanidine compounds. (Talyor et al.,2002)

Many researchers also experimented with the antimicrobial efficacy of Zinc oxide and Copper oxide nanoparticles in alginate impression materials. They suggested that these nanoparticles were also proved to be effective self-disinfecting agents for alginate impression materials without a destructive effect on physical and mechanical properties. (Ginjupalli et al.,2018)

Recently, researchers have experimented with incorporating different antimicrobial nanoparticles into alginate impression materials. numerous research has suggested that the addition of silver nanoparticles is greater effective against S. aureus, Lactobacillus acidophilus, Actinomyces viscosus, and Pseudomonas aeruginosa. (Jafari et al.,2013;Tellapragada et al.,2016)

2.3.5.6. Storage medium for alginates

Conventional alginates are dimensionally unstable due to syneresis and imbibition. Hence, it is necessary to pour the gypsum cast as soon as possible after the impression is removed from the mouth.(Srivastava et al.,2012)

A storage solution is now available to store the alginate impressions without any dimensional changes. It was reported that storage of alginate impression in that solution did not show significant dimensional changes up to 100 hrs.(Walker et al.,2010)

2.3.5.7. Other modifications

The other drawback with the alginate impression materials is its shorter mixing time. Hence, the operator should be professional sufficient to mix the alginate material in the shorter mixing time to obtain homogenous consistency and make a correct impression.

Mechanical or automated mixing devices had been developed to deal with this problem, where mechanical mixing devices give extra accurate consistency in a shorter time in comparison to hand mixing. (Nandini et al.,2008)

The traditional alginates on mixing with water have a tendency to form a grainy mass with lumps of unmixed material because the water does not wet the powder easily. A thickening and stabilizing agent which include 0.01-0.25wt% polyacrylamide (molecular weight-200,000 to 6,000,000) were incorporated into the conventional alginates leading to enhancing the mixing characteristics, and the formation of smooth alginate sol with water. (Pellico, Michael ,1984; Pellico, Michael ,1986)

2.4. Elastomeric impression materials.

In the middle 1950s, elastomeric impression materials were introduced. (Starke ,1975) Excellent detail reproduction, dimensional stability, and suitable tear strength are the characteristics of elastomeric impression materials that made those materials used when a high degree of accuracy is essential. (Kareem et al., 2016)

Four basic kinds of elastomeric impression materials are currently in use in the dental profession:

(1) polysulfide (mercaptan) rubbers, (2) polyethers, (3) silicone rubbers which polymerize by a condensation reaction, and (4) silicones which polymerize an addition reaction. The latter was introduced relatively recently and also are known as polyvinylsiloxanes. (Lacy et al.,1981)

In the last decade, several investigators have recommended using newer elastomeric materials such as polyvinylsiloxane and polyether for final impressions to replace the older and more traditional materials (Chee and Donovan, 1992; Petrie et al., 2005)

Elastomers can present in different consistencies, including putty, heavy body, medium body, and light body where the putty type is available in two jars containing base and catalyst; the medium body is dispensed in two collapsible tubes as base and catalyst; the light body in syringes.(Gomez-polo et al.,2012)

2.4.1. Polysulfides (Mercaptan, Thiokol)

These were the first really accurate elastomeric materials to be introduced to general use in the early 1960s. (Smith et al.,1986) Polysulfide materials had higher dimensional stability and tear strength than hydrocolloids. They need to be poured as quickly as possible after impression making, delays of over an hour led to significant dimensional change, and it has improved dimensional stability over hydrocolloid (inferior to polyether and addition silicone). (Kyfe ,1994)

Polysulfides have a long working and setting time, that's an advantage while impressions are being taken of multiple preparations, but a disadvantage while only one or two teeth had been prepared. Its disadvantage of a long setting time in the mouth induces poor patient acceptance (mainly in view of its unpleasant sulfide odor). (Smith et al.,1986)

Other disadvantages of the polysulfides include the need to use custom-made instead of stock trays because of a greater risk of distortion, a bad odor, a tendency to run down the patient's throat due to decrease viscosity, and the lead dioxide materials that stain clothing. (Joshi et al.,2009)

2.4.2. polyether

Since, the introduction of polyether in 1969, it has helped clinicians to achieve accurate and dimensionally stable impressions. Polyether impression materials are composed of moderately low molecular weight polyether, a silica filler, and a plasticizer and have excellent wettability. (Perry et al.,2006)

Being hydrophilic absorbs water or fluids, and also is a rigid material with a high modulus of elasticity which makes it extremely hard to remove from undercut areas, and high cost, short working and setting time, and high stiffness after setting restrict their use. (O'Brien ,2002)

2.4.3. Silicone impression materials

Silicone impression materials are categorized according to their technique of polymerization on the setting, into condensation curing (or Type I) silicones and addition curing (or Type II) silicones.

Silicone rubbers are available in different variety of viscosities to light, medium, heavy, and putty). The high filler loading of the putty was devised to reduce the effects of polymerization shrinkage. (Craig ,1997)

Availability of the silicone-based materials in different viscosities, permitting them to be utilized in numerous impression strategies adequate to improve the mold accuracy, such as the 1-step putty/light-body technique, 2-step putty/light-body technique, and the monophase method. (Saunders et al.,1991;Nissan ,2000)

The 2-step putty/light-body method was created to reduce the shrinkage of the condensation silicones. (Hung et al.,1992)

2.4.3.1. Condensation silicones (Polysilixone)

The traditional silicone impression materials also are referred to as condensation reaction silicones.(Shilling burg et al.,1981)

Condensation silicone is obtained by cross-linking polycondensation reaction of hydroxyl terminated polysiloxane pre-polymers with tetra alkoxy silanes catalyzed by dibutyl-tin dilaurate, (DBTD). The polycondensation procedure releases alcohol that contributes to the contraction (reduction) of the impression. (Islamova et al.,2016)

The advantages of the condensation silicon are precise impression if poured fast after it is taken and good elastic restoration after removing the impression from the mouth. However, its disadvantages are: hydrophobic, contraction of the impression with the lapse of time and possible hypersensitive reaction due to the catalyst. (Rubel ,2007; Chen ,2004)

The primary drawback of condensation silicone, it's bad wetting characteristics. Hence, their hydrophobic nature requires their use in a dry, clean field, so the prepared teeth and gingival sulci need to be completely free of moisture for a defect-free impression. Pouring without trapping air bubbles is also more difficult than with different impression materials, and a surfactant can be needed. (Kyfe,1994)

The condensation silicones have greater shrinkage on setting than other rubber impression materials. Its dimensional stability is less than that of polysulfide although greater than that of reversible hydrocolloid. Condensation silicone and polysulfide have dimensional instability this is because of their mode of polymerization.(Charbeneau,1988;Rosenstiol et al.,1988)

As with the polysulphides, the setting reaction of the condensation-cured silicones produces an unstable by-product, but with type I silicones, it is ethyl alcohol, not water. Loss of the by-product results in a measurable weight loss of the impression this is accompanied by shrinkage of the impression material on storage. (Brown ,1981)

2.4.3.2. Addition silicones (polyvinylsiloxanes)

The polyvinyl siloxane impression materials are addition reaction silicone elastomers which had been first introduced in the 1970s. (Mandikos ,1998)

Addition silicones (polyvinyl siloxane) have a moderately low molecular weight silicone that contains silane groups that bind collectively in a network of chains that provide material a rubber consistency. Polyvinyl siloxane (PVS) impression materials represent the state of the art in elastomeric impression materials in prosthodontics and restorative dentistry. (Craig , Sun ,1994; Perakis et al.,2004)

Polyvinyl siloxane (PVS) impression materials used for recording the impressions of dentulous and edentulous arches, duplication of casts and bite registrations. Recently, new elastomeric impression materials with very high elastic recovery and high tear strength have been introduced. (Surapaneni et al.,2013)

Advantages: Excellent dimensional stability, desirable tear strength, desirable working and setting times, excellent wettability, auto mixed system, short setting time, adequate tear strength, extremely high accuracy, minimum distortion on removal, dimensionally stable even after 1 week, If hydrophilic, desirable compatibility with gypsum. There are no reports of patient sensitivity to the addition silicones.

Disadvantages: Hydrogen gas release, inhibition of setting by sulfur-containing materials, expensive, Hydrophobic & hence requires a completely dry field .(Surapaneni et al.,2013)

Early generations of VPS impression materials released hydrogen gas after setting, which required a delay in the pouring of casts to avoid bubbles. This problem has been resolved by adding platinum or palladium to scavenge the gas, and this improvement has allowed the immediate pouring of casts without bubbles or voids. (Nam et al., 2007)

Their major advantages are low polymerization shrinkage, long-lasting dimensional stability and endurance, and a lack of toxic or allergenic behaviors. Impression detail is influenced by factors such as viscosity, wettability, handling properties, and the presence of voids. Two main characteristics of the impression material are accuracy and dimensional stability. (Surapaneni et al.,2013)

2.4.3.2.1.Composition and chemistry of Polyvinylsiloxane

Polyvinylsiloxane is often called ‘viny polysiloxane’ (or VPS) as well. Since it is based on silicone chemistry it has sometimes been mentioned as an addition-silicone. Polyvinyl siloxane materials are a modification of the original condensation silicones. Both are based on the polydimethylsiloxane polymer, but the presence of different terminal groups accounts for their different curing reactions. (Van Noort,2013)

The base material consists of a polymethyl hydrogen siloxane copolymer, that's a moderately low molecular mass polymer with silane terminal groups. The accelerator material consists of vinyl-terminated polydimethylsiloxane. This is also a moderately low molecular mass polymer but has vinyl terminal groups. (Craig ,1993;Van Noort,2013)

The accelerator material also contains chloroplatinic acid as a homogeneous metallic complicated catalyst.(Williams, Craig ,1988; O' Brien ,1989) The base and accelerator paste also contain fillers. Amorphous silica or fluorocarbons are used as fillers to add bulk and enhance the properties of the paste. The filler is also generally silanated to increase the bond strength among filler and polymer, which better allows it to function as across – linker. (Williams, Craig ,1988)

Coloring agents are added to differentiate the base and catalyst pastes and to aid the evaluation of mixing. The intrinsic surfactants have also been added in an attempt to negate the hydrophobicity of those substances. (Panichuttra et al.,1991)

Polyvinyl siloxane are available in viscosities starting from very low (for pouring, syringing, or wash use), to medium, high, and very high. The viscosity of the material increased with increase the percentage of filler .

2.4.3.2.2.Setting Reaction

On mixing, an addition reaction occurs among the silane and vinyl groups, there is a cross-linking of a vinyl terminated poly dimethyl siloxane catalyzed by a platinum salt (chloroplatinic acid). Hydrogen gas is a byproduct of the polymerization reaction.

Several authors have reported hydrogen gas bubble formation on the surface of gypsum dies poured immediately from polyvinyl siloxane impressions, hydroxide groups in many products produce hydrogen gas, resulting in small bubbles on the model surface if pouring isn't delayed by 30-60 minutes. (Surapaneni et al,2013)

Many of those addition silicones contain catalysts like palladium that absorb this hydrogen. Manufacturers have now removed the possibility of this side reaction through proper purification and correct proportioning of the materials, and by the addition of palladium to the pastes as a hydrogen absorber. It is now not important to wait for one hour before pouring those impressions.(Surapaneni et al,2013)

Modern polyvinyl siloxanes have a working time of two minutes and a setting time of six minutes (with mild variation). They are more sensitive to temperature than polysulfide, may be prolonged by cooling or adding retarder. The ratio of base: Accelerator does not alternate working & setting time and these times are considered to be good enough if not ideal, so alteration of the proportion of catalyst is to be prevented as this results in variable effects and has been suggested to facilitate the side reaction which produces hydrogen gas. (Surapaneni et al,2013)

Some manufacturers supply a retarder that may be integrated into the mix to provide extra working time without compromising different properties(Chee, Donovan,1992) The retarder is a small, reactive, tetracyclic vinyl molecule that polymerizes preferentially to the siloxane copolymers. This small molecule is cyclic and does not form a chain and acts as a chain stopper, that temporarily prevents polymerization of the linear siloxane molecules and then continues to polymerize until it is completely consumed after which the linear siloxane molecules polymerize causing the impression material to set.

The maximum convenient and broadly encouraged approach for extending working time is to refrigerate the materials before mixing. Gains of up to 90 seconds were reported when the materials are chilled to 2°C (Chee , Donovan , 1992; Chew et al.,1993)

It is a good idea to store the addition silicones in a fridge and use them immediately after removal because the cool storage conditions act to extend the working time by approximately 1.5 mins without adversely affecting the material’s accuracy.

The accuracy of impression material is depending on dimensional stability. There are some possible reasons for dimensional changes in elastomeric impression materials. The main factors affecting the dimensional change of the impression are thermal contraction, polymerization shrinkage, and contraction because of the lack of volatile by-products. (McCabe, Storer ,1980)

Polyvinyl siloxanes display the smallest dimensional changes on the setting of all the elastomeric impression materials because they're not liable to changes in humidity and they do not undergo any further chemical reactions or release any by-products.(Surapaneni et al.,2013)

Tjan et al evaluated the accuracy of monophase polyvinyl silicones and found that repeat pour at later time periods, did not have an effect on the dimensional accuracy and stability of impression made with those materials. (Tjan et al.,1992)

Polyvinyl siloxane impressions can be repoured to provide stone dies which are as accurate as the original, as many as seven days later. (DeWald et al.,1994)

Addition silicone impression materials have a polymerization shrinkage lower than condensation silicone materials..(Braden,1976;McCabe,Wilson,1978;McCabe,Storer ,1980)

2.4.3.2.3. Gloves and the inhibition of polymerization:

An inhibition or retarding effect was seen on polyvinyl siloxanes when they are utilized in a clinical setting. This phenomenon can arise after direct touch among the impression material and latex gloves, or an area of the mucosa previously touched by latex gloves. (Duncan ,1991; Kahn et al.,1989)

A sulfur compound has since been recognized as being responsible for the retarding effect on polymerization. Zinc diethyldithiocarbamate is an accelerator used in the manufacture of latex gloves, where it reacts with the platinum catalyst in the polyvinyl siloxane to cause a delay or general inhibition of polymerization. (Kahn et al.,1989; Causton et al.,1993;Baumann ,1995) Baumann reported that even in concentrations as low as 0.005 percent, general inhibition of polymerization of polyvinyl siloxane can be observe.

2.4.3.2.4.The hydrophilic property

The hydrophilicity of the impression materials is critically important to wet the hard and soft tissues in the mouth and to create accurate impressions and casts.(Kess et al.,2000)

According to O’Brien, wetting describes the relative affinity of a liquid for a solid. It is the degree to which a drop will spread on a solid surface, and may be quantified by watching the contact angle. High angles (more than 90 degrees) indicate poor wetting, whilst a 0 angle would indicate perfect wetting of the surface. (O’Brien,1989)

So, Impression materials are characterized by their degree of hydrophilicity. They can be hydrophilic, hydrophobic, or hydroactive. (Pitel ,2005)

Polyvinyl siloxane (addition silicone) are hydrophobic due to their chemical structure, where they contain hydrophobic aliphatic hydrocarbon groups around the siloxane bond. (Giordano,2000) so, the hydrophilization of polyvinyl siloxanes is better with the incorporation of nonionic surfactants which have a hydrophilic part and a silicone-compatible hydrophobic part.

These surfactants act through a diffusion transfer of surfactant molecules from the polyvinyl siloxane into the aqueous phase. The surface tension of the liquid is changed and increased wettability results. (Zardiackas ,2007)

Recently, vinylsiloxanether (VSE) products have been commercially introduced. These elastomeric impression materials are mixtures of the most desired properties from the addition silicone and polyether impression materials into one material. This has been claimed by the manufacturer to possess ideal mechanical and flow properties and those products are hydrophilic during setting and after polymerization. They are supplied as a 2-paste auto mixing system. (Abdulsamee , Hussein ,2017)

2.4.3.2.5. Disinfection

Microorganisms able to cause disease are found in human blood, Where the contact with blood or saliva mixed with blood may also transmit pathogenic microorganisms. (Van Noort ,2013) Set impressions are a source of pathogens that contain microorganisms bacteria, fungi, and viruses following their removal from the patient's mouth, where these microorganisms are transmitted into plaster and stone while models are being poured. These models represent a risk of disease transmission to dental healthcare workers, transporting personnel, and laboratory personnel via indirect contact.

Therefore, the perfect infection control protocol needs to be followed before, during, and after impression making to avoid cross-infection and the risk of disease transmission. (ADA Reports update,1991)

Disinfectants used must be as effective as antimicrobial agents, and not adversely have an effect on the dimensional accuracy of impression material. (Guiraldo ,2012) Various disinfectants are suggested for disinfecting impression materials such as sodium hypochlorite, glutaraldehyde, iodophor, and phenol. (Walker et al.,2007)

The addition silicone impression material was disinfected by being Immersed in 2% glutaraldehyde for 1 hour, rinsed in sterile water.(Sumanth et al,2019)

2.5. Dimensional stability and accuracy

Dimensional stability and accuracy of the impression are taken into consideration to be the most important factors because they directly affect the fabrication of prosthesis. (Thomas et al.,2016) Accuracy is the ability to reproduce the details of the impression. (Van Noort ,2013) Dimensional stability is the strength of the impression material to keep its accuracy before the pouring process. (Ocarina, Raharja ,2018)

The dimensional changes of impression materials may have an effect on the quality of fit and retention of dental prosthesis, which influences the success of the indirect restorative procedure. (Shah et al.,2004)

Several factors have an effect on the precision of impression materials, they include; impression material manipulation, type of impression material, tray impression retention, thermal changes after removal, tray deformation, impression material thickness, impression tray design. (Shisheyan et al.,2016)

Also, the dimensional behavior of impression material is influenced by the time interval from mixing to pouring, humidity, and the kind of polymer comprising the elastomers. The impression technique may be done by the use of single or double steps, which can result in different outcomes with respect to dimensional accuracy. (Gonçalves et al.,2011)

Generally, the dimensional stability of alginate mold may be influenced by internal and external factors. One of the internal factors is the composition of alginate impression material, and the external factors are the storage time and storage procedures.(Van Noort , 2013;Craig et al.,2008)

Numerous research considered the time as the most important factor affecting the dimensional stability of the alginate. For reasons such as the inaccessibility of the laboratory and the preference of most dentists to transfer the impression to the laboratory, there might necessarily be a delay between the elimination of the alginate impression from the patient's mouth and the pouring of its cast.

On the other hand, another delay was mainly because of the technician's ignorance in the laboratory in terms of fast pouring of impression. These factors collectively could result in dimensional changes in the obtained mold and inadequate replica of the resulting restorations in the oral environment. (Mousavi et al., 2019)

The different factors that affect the dimensional stability of alginate include; syneresis: if hydrocolloid impression is left in the air it's going to lose its water content material by evaporation from its surface or by exudation of fluids at the surface, lack of water or fluids is observed by shrinkage of the impression, imbibition: if hydrocolloid that lacking in water content is placed in touch with water, absorption of water will occur swelling of the impression , ratios of calcium to sodium and filler to polymer, a molecular weight of alginic polymers and different proprietary constituents. (Imbery et al.,2010)

PVS materials possess ideal dimensional stability, Because there is no by-product to the chemical setting reaction of addition silicones, they may be poured at the convenience of the operator and are the impression material of choice if the impression is to be sent to the laboratory where the dentist loses control of when it is poured. PVS impressions can be poured immediately after elimination from the mouth, or hours, days, and even weeks after making the impression. (Donovan , Chee ,2004)

Generally, there are 3 methods are used to evaluate the accuracy of an impression material:

1. Using in-vitro models for evaluation of dimensional accuracy of impression materials.
2. Evaluating marginal fitness of crowns on models.
3. Comparing dimensions of cast with the master model.(Parviz et al.,2017)

Acceptable techniques of measuring the dimensional accuracy of casts include measuring with calipers, microscopes, micrometers, dial gauges, and digital modeling and there is no general agreement as to which measuring tool is best.(Gu¨mu¨s et al.,2014) also, three-dimensional (3D) computer dental models, generated with optical or laser beam scanning, appear suitable for dental cast measurements in the clinical setting. (Alkurt et al.,2016)

Manual measurements, perform with vernier calipers or needlepoint dividers, are the standard technique for evaluating the accuracy of the resulting dental casts. The manual measuring strategies have a number of advantages such as simple application, low price, and is easily available. However, they're taking a lot of time and the measurement accuracy may be adversely affected by operator fatigue and error.(Gu¨mu¨s et al.,2014; Alkurt et al.,2016)

Özkalayci et al (2017) Measured all stone models and master models manually with digital calipers and scanned them with a digital scanner (3Shape TRIOS® Ortho, 3Shape, Denmark) and analyzed with a proper computer program (Ortho Analyzer™ Software, 3Shape, Denmark) in comparison of the digital with manual measurements, outcomes confirmed that there were no statistically significant differences among those methods. (Özkalayci et al.,2017)

2.6. Tear strength

Tear strength is "the ability of the material to resist tearing under tensile stress". When the impression material is removed from the oral cavity or from gypsum models, it is subjected to tensile stresses. (Haider et al.,2018)

The tear strength becomes essential when areas with undercuts are impressed. The higher the tearing energy, the less possible it is for the material to tear in a place with existing undercuts. (Haider et al.,2018)

Impressions need to resist tearing whilst tensile stresses are applied during impression removal and cast separation from the set impression. Impression materials are most susceptible to tearing in gingival crevices and interproximal regions. Tearing withinside the impression causes defects, which have an effect on the accuracy of the final restoration. (Sheta et al.,2017)

The tear strength of impression materials has been measured using numerous different tests, there are three strategies that are common in compliance with ISO 34 tear test, namely:

1.Trouser test piece (method A)

A trouser test piece consists of a rectangular strip 15 x 75 mm with a notch 25 mm in from one short side. The strip is elongated in a tensile tester with 100 mm/min, so that the notch gets bigger.

2.Angle test piece (method B)

A 90° angle test piece is elongated using a speed of 500 mm/min to break. The test can be performed with a 1 mm nick or without a nick the test without the nick measures a combination of the force of tear initiation and propagation.

3.Crescent test piece (method C)

A crescent shaped test piece with a 1 mm deep nick is elongated using a speed of 500 mm/min to break. The test can be considered to be a tensile test with an indication of fracture. The result is given in kN/m (N/mm) test piece thickness. (Spetz ,2016)

The trouser tear test, the most commonly used approach to evaluate tear strength, was pioneered by Griffith (1920) and developed by Rivlin and Thomas. (Rivlin ,Thomas ,1953)

They introduced the simple extension tear test piece, which was later adapted to the trouser tear test of a dental impression material by Webber and Ryge. (Gonçalves et al.,2011) and a trouser tear specimen, so-called as it resembles a pair of men's trousers. (Ciullo , Hewitt ,1999)

Tear strength is expressed as force per unit of specimen thickness-pounds force per inch (Ibf/in), kilograms force per centimeter (kgf/cm), kilonewtons per meter (kn/m), or Newton per millimeters (N/mm).(Ciullo , Hewitt ,1999; Millar , Deb , 2014)

The tearing rate is the speed at which the materials are eliminated from the mouth or the cast from the impression. Elastomeric impression materials are viscoelastic, and the tearing rate will have an effect on the tear strength of the material.

Clinically, the velocity at which impressions are eliminated from the oral cavity and the cast will have an effect on the tear strength of the impression material. Therefore, the impression should be removed with the fastest possible speed. (Lawson et al.,2008)

The amount of force needed to tear a specified test specimen divided by the thickness of the specimen is referred to as the tear strength. (Kenneth et al.,2013)

It is very critical that alginate has sufficient strength in order to do not tear upon removal from the mouth. Factors that contribute to alginate gel strength are P/W ratio, mixing time, time of elimination from the mouth, and rate of removal from the mouth.
Clinically, the initial set of alginate is determined by a lack of surface tackiness.
(Fayaz, Noori,2016)

Two components of alginate powder in relation to strength are diatomaceous earth and alginic acid. diatomaceous earth or silicate which constitutes more than half the components and act as a filler to increase the strength and stiffness of the alginate gel.(Kenneth et al.,2013)

Adequate tear strength is important. Thin regions of material have to resist tearing upon removal from the mouth when separating the model and the impression.(Farah J, Powers J,2003) Polyethers are considered to have the highest tear strengths, while hydrocolloids have relatively low tear strengths. (Kenneth,2003) Polysulfide impression materials have a high resistance to tearing but stretch and do not recover completely elastically. (Giordano ,2000)

Research Objectives

Aim of the study :

1. To evaluate the effect of repeated pour on dimensional accuracy of impression made from alginate impression materials and compare it with addition silicone.

2. Evaluate the accuracy after delay of pouring according to time of day stability recommended by manufactures (Five-day stability alginmax, Nine-day stability cavex color change).

3. To evaluate the effect of thickness on tear strength of different types of alginate impression materials (conventional type, alginmax, cavex color change)

Materials

&

Methods

3.Materials and Methods

3.1. Materials

3.1.1. Impression materials :

Impression materials had been selected for this study used routinely by many dental practitioner. Three types of alginate impression materials (conventional type, cavex color change, alginmax) Addition silicone affect material (Elite HD+) Figure 3.1 shows the impression material used in this study.

3.1.2. dental stone

Type Ⅲ dental stone was used to pour the alginate and silicone impressions.

Different materials used in this study are illustrated in (Table 3.1).

3.1.3.Equipment: Universal test machine, digital caliper, acrylic study model, rubber bowl, spatula and perforated plastic trays**.**

Table 3.1: The materials that used in this study.

Products	**Type**	**Manufacturers**
Phase plus	Alginate	Zermack,Italy
Alginmax	Alginate	Major Prodotti , Italy
Cavex color change	Alginate	Cavex, Holland
Elite HD+	Addition silicone	Zermack,Italy

Figure 3.1.show A,B,C: alginate impression materials and D: addition silicone material

3.2. Methods:

3.2.1. Dimensional accuracy

3.2.1.1. Evaluate dimensional accuracy after repeated pouring.

In this study 40 samples had been prepared by taking impressions from an acrylic master model representing an edentulous maxillary arch (Figure 3.2, a) with Four reference points (A, B, C, D) had been fabricated using posts with x form grooves scored on its the occlusal surface, those posts positioned in areas approximate position of the incisal papilla, left and right second molars and in the middle of the hard palate.

I. Impression making from alginate impression materials.

Alginate materials had been manipulated according to the manufacturer's instructions a volume of water was added to alginate powder: for alginmax:

2 scoops of powder(19g) added to 2 scoops of water(40 ml) and for cavex color change: 3scoops of powder(21g) added to (45 ml) of water for conventional phase plus alginate:2 scoops of powder(18g) added to (36 ml) of water.

They were mixed by adding a suitable amount of water into a rubber bowl (tape water at room temperature) then alginate powder had been added to the water, they were mixed vigorously- by spreading and squeezing the material against the internal side of the bowel used the spatula.

Immediately after mixing, the irreversible hydrocolloids had been placed in a stock perforated plastic tray(Figure3.2,b) ,then the impression is taken to the master model "extreme care was taken to apply the same amount of material into the stock tray for each sample and the same seating sample of the master model was used for each impression to attain a constant thickness of materials".

After the gelation, the tray was carefully removed with a snapping motion. the impressions had been rinsed with tap water at room temperature. (Figure 3.2,c)

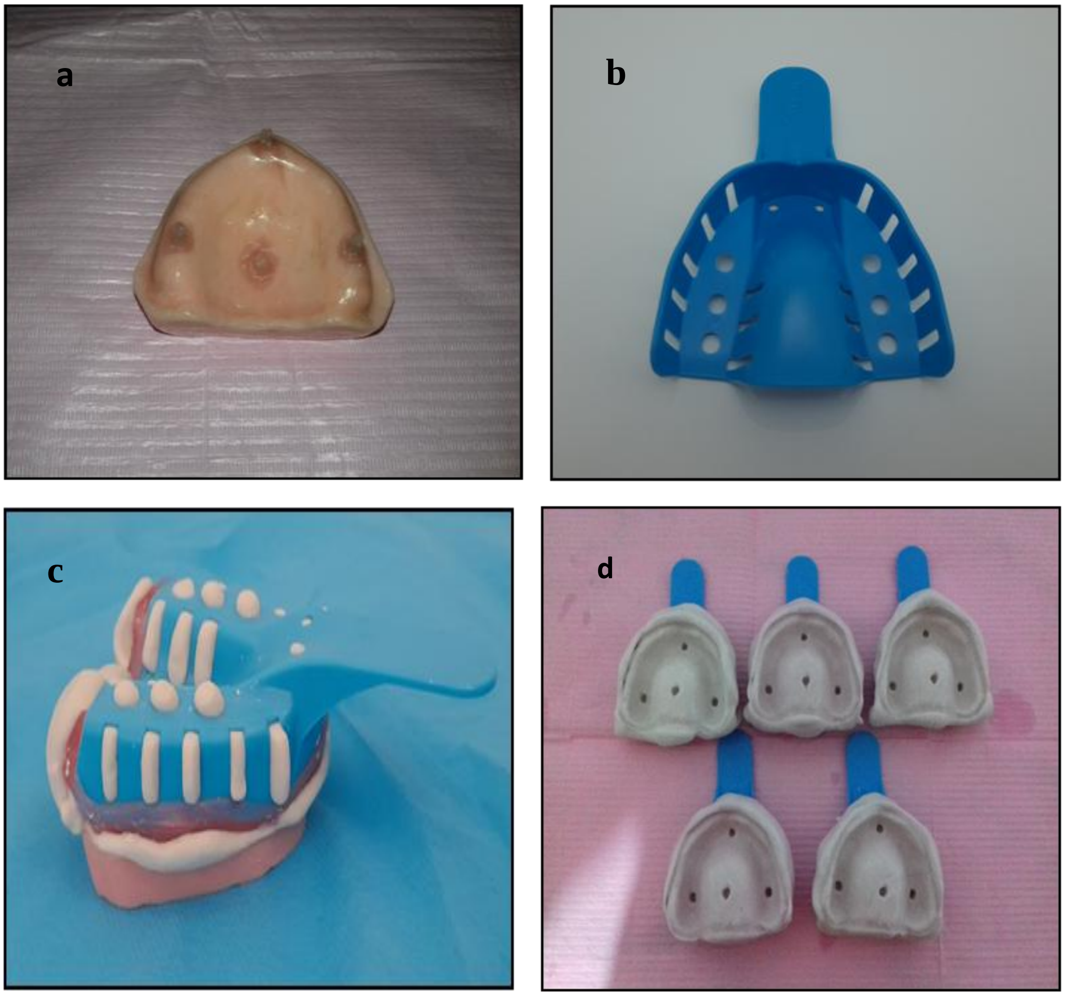

Figure 3.2: a: Master model. b:Perforated plastic tray. c: Making impression for the master model. d: Alginate impressions.

II. Polyvinylsiloxane materials (Elite H+) :

A two-step putty-wash impression technique was used for making impressions of the master model using addition silicone impression materials, Putty impression materials (base and catalyst) were mixed according to manufacturer's instructions and were loaded into the tray to make an impression of the master model, all materials were mixed by hand without gloves.

After putty was set, the tray was removed vertically, followed by mixing wash materials. For Elite H + light body, equal length of base and catalyst paste were dispensed directly on clean mixing paper pad and mixed with clean stainless-steel spatula, then they were introduced into the putty impression, the tray was again seated on the master model until the wash material set , then it was removed with vertical movement. The silicone impression materials were rinsed with tap water and then poured (Figure 3.3) shows steps of putty wash impression technique.

III. Cast preparation:

All impressions were poured with dental stone type Ⅲ (Dentstone,Egypt) according to the manufacturer's instructions. The 100g of powder were added to 30ml of water and mixed in rubber bowel with a spatula, the mixing was gradually poured onto the impressions surface under vibration to remove air bubble, after covering all the critical surfaces of the impression a large amount of the mix added and the base make, the poured casts were left to set for 1 hour after that removed from the impression, casts were allowed to dry for further 1 hour to ensure a complete set before measuring them. (Figure 3.4)

Again after the impression was removed from the cast, the same impression was repeated pour immediately, considered as a second pouring. this step was applied to all impression materials.

Figure 3.3:Steps putty wash impression technique

Figure 3.4:a: Cast preparation. b:The impression removed from the cast

c: The first pour casts & d: The second pour casts

IV. The dimensional accuracy measurement.

In this study acrylic edentulous maxillary typodont was used as master model. four reference points were determined on the model and measured as show in (Figure 3.5). (Rohanian et al .,2014)

1st Dimension: (A__B) extent from the post situated at area between central incisor to other post situated at left molar region.

2nd Dimension: (A__C) extent from the post situated at area between central incisor to other post situated at right molar region.

3rd Dimension: (A__D)) extent from the post situated at area between central incisor to other post situated at palate.

4th Dimension: (B__C) extend from the post that situated at left molar region to post on the right molar region.

5th Dimension: (B__D) extend from the post situated at left molar region to the post located at palate

6th Dimension: (C__D) extend from the post located at right molar region to the post located at palate.

The measurements were recorded by one operator using digital calipers (Figure 3.6). To establish reproducibility of the measurements, three readings have been taken for every linear measurement (A—B, A—C, A—D, B—C, B—D, C—D) among the intercept of the 'x' at the posts of every model, eighteen measurements for every cast.

The measurements of the first poured cast have been used as a control. The mean of the three linear measurements taken from the gypsum casts as compared to those recorded from the first pouring casts. Data will analyze using analysis of variance (ANOVA) to determine the level of significance .

V. Statistical analyses of data

Statistical analyses were conducted. A Two -way analysis of variance (ANOVA) was used to assess the effects of the repeated pour on the dimensional stability, The level of significance was set at **p = 0.05** for all statistical analysis.

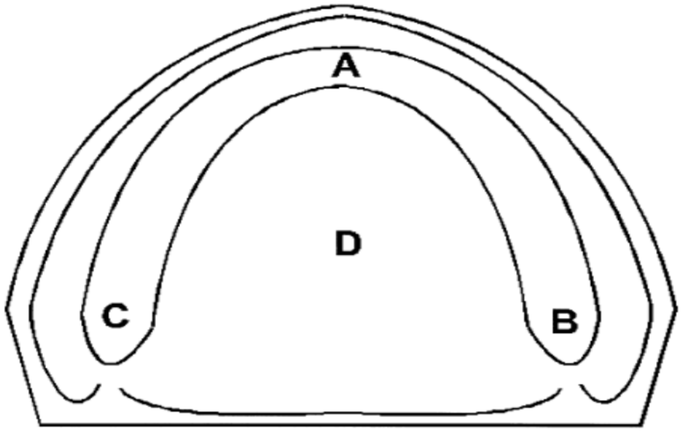

Figure. 3.5. Diagrammatic representation of the master model constructed to represent an edentulous maxillary arch. Dimensional accuracy of casts will determine by measuring between the reference points (A—D)

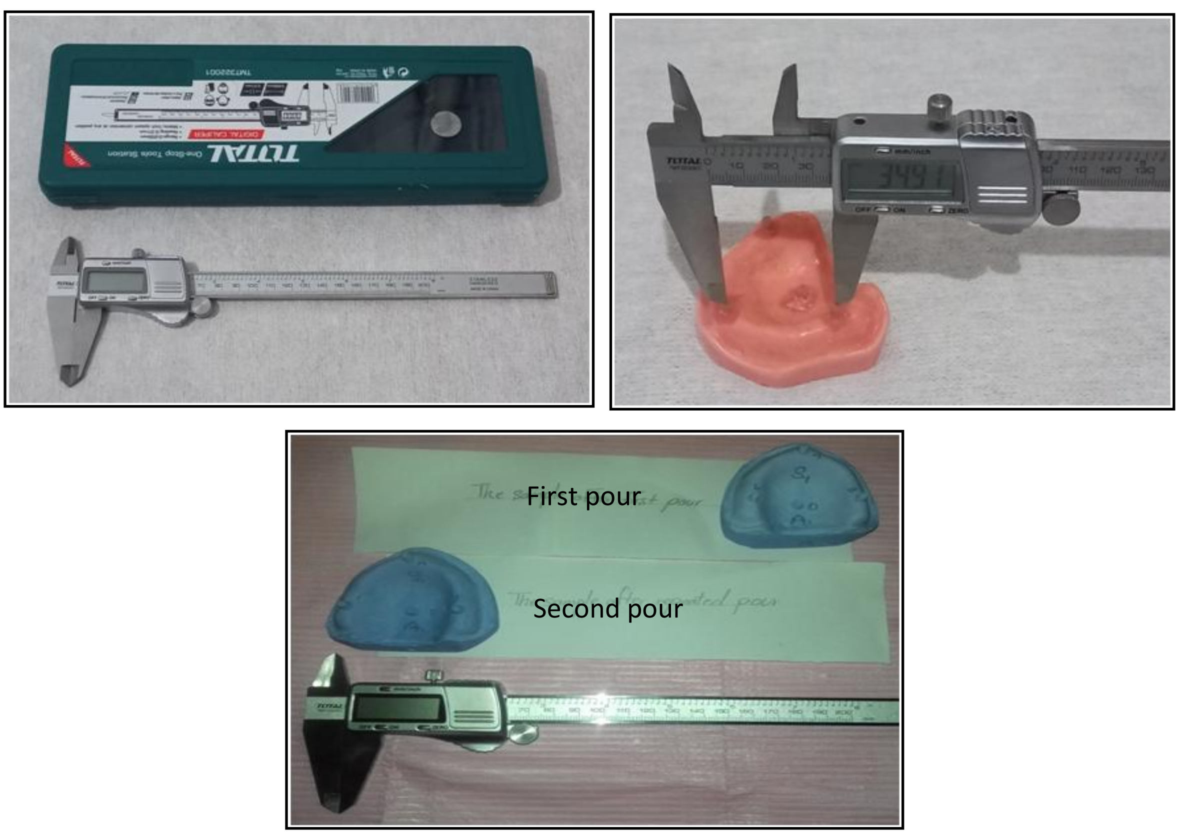

Figure 3.6:Shows digital caliper, different pouring casts

3.2.1.2. Evaluate accuracy after delay pouring:

In this study, 40 samples have been prepared by taking impressions from an acrylic master model representing an edentulous maxillary arch equal to that utilized in the preceding test, 5 samples for each type of impression, two types of alginate impressions used : Cavex color change (9 days stable alginate, Italy) and Alginmax (5 days stable, Italy)

I. Impression making

Alginate materials had been manipulated and mixed according to manufacturers' instructions and prepared as described previously by one operator.

Immediately after mixing, the irreversible hydrocolloids had been placed in a stock perforated plastic tray (Figure 3.3) to impression the master model. After the gelation, the tray was carefully removed with a snapping motion. Impressions had been rinsed with tap water and stored in sealed plastic bags at room temperature for the storage periods (3 hours, 3 days, 5 days, and 9 days).

II. Cast preparation

Impressions had been poured at different times (three hours, three days, five days, and nine days). the samples had been divided into 4 groups:

Group 1: were poured after three hrs

Group 2: were poured after three days

Group 3: were poured after five days

Group 4: were poured after nine days

Ten specimens for every group, five impressions from every brand. All impressions had been poured with dental stone type III (Dentstone,Egypt) according to the manufacturer's instructions, The 100g of powder were added to 30ml of water and mixed in a rubber bowel with a spatula, the mixing was gradually poured onto the surface of the impression under vibration to remove air bubble, after covering all of the critical surfaces of the impression a large amount of the mix added and the base make, the poured casts had been left to sit for 1 hour after that removed from the impression, casts had been allowed to dry for a further 1 hour to ensure a completed sit before measuring them.

III. The Dimensional accuracy measurement.

In this study acrylic edentulous maxillary typodont was used as master model. Four reference points were determined on the model and the measurement of delay pouring casts was done as shows in the Figure 3.5.

1st Dimension: **(A__B**) extent from the post located in the area between the central incisor to other post located in the left molar area.

2nd Dimension: (**A__C**) extent from the post located in the area between the central incisor to other post located in the right molar area.

3rd Dimension: (**A__D**)) extent from the post located in the area between the central incisor to other post located at the palate.

4th Dimension: (**B__C**) extend from the post that is located at the left molar area to the post at the right molar area.

5th Dimension: (**B__D**) extend from the post located at the left molar area to the post positioned at the palate

6th Dimension: (**C__D**) extend from the post positioned at the right molar area to the post positioned at the palate.

The measurements were recorded by one operator using digital calipers. To establish reproducibility of the measurements, three readings had been taken for every linear measurement (A—B, A—C, A—D, B—C, B—D, C—D) between the intercept of the ‘x’ at the posts of each model, eighteen measurements for each cast. The measurements of the immediate cast (zero time) had been used as a control.

The mean of the three linear measurements taken from the gypsum casts was in comparison to those recorded from the immediate casts. Data will analyze using analysis of variance (ANOVA) to determine the level of significance .

IV. Statistical analyses of data

Statistical analyses were conducted. A two-way analysis of variance (ANOVA) was used to assess the effects of the each material and storage period on the dimensional stability, followed by a Tukey test among groups. The level of significance was set at **p = 0.05** for all statistical analysis.

3.2.2.Tear strength

I. Preparation of the speciments for tear strength test.

Forty-five strips were prepared for the "trouser-method" test (in compliance of ISO 34-1) for tear strength analysis.

A metal mold (Figure 3.7) was used to make rectangular samples with dimensions of (75mm length, 25mm width) with three different thicknesses (2mm,3mm,4mm) All materials were mixed according to the manufacturer's instructions.

To make a sample, a metal mold was positioned upon a sheet of glass and the rectangular cavities of the mold had been filled with mixed materials, then covered with a glass plate and pressure was applied on it using (about 5kg) weight to facilitate the material's flow and ensure the constant thickness of materials, after setting of material completely, the glass plate was removed and the specimens had been removed from the mold (to avoid of sticking of the materials to the glass on the time of removal; the glass sheets were covered with a cellophane tape), the excess materials from the edges of the specimens had been trimmed using a pair of scissors (Figure 3.8) an incision measuring 10 mm was made down the center of the specimen to make a trouser shaped piece. discard any specimen with a defect such as big pores and make a new one.

For tear strength analysis, these strips were divided into three main groups (G1, G2 and G3) according to type of impression materials and each group were divided into three subgroups according to thickness of these impression materials.

Group 1: measure tear strength of Alginmax with thickness :

G1 A= 2mm, G1 B = 3mm, G1 C = 4mm

Group 2: measure tear strength of Cavex change color material with thickness:

G2 A= 2mm, G2 B = 3mm, G2 C = 4mm

Group 3: used as control group (Conventional alginate):

G3 A= 2mm, G3 B =3mm, G3 C = 4mm

II. Testing of tear strength.

Tear testing was done with the use of a universal testing machine [Instron. prodit, Italy] (Figure3.9) Provided by College of Mechanical Engineering Technology(Benghazi-Libya).

Forty five strips of alginate materials had been prepared as described previously, the trouser-shaped parts of each sample had been held in location with clamps and tension done in 100mm\ min rate, the clamps had been moved in opposite directions till the sample is completely torn; at that time pressed on the stop button and recorded the maximum force that displays at the screen. After that press on return button and a new sample is attached to the machine clamps and measured in the same way, and so till all samples are measured. Tear strength (T) was calculated from:

$T = 2F/t$ Where (**T**) is the tear strength (N\mm), **F** the force (N), and **t** the thickness (mm).

III. Statistical analyses of data.

Statistical analyses were conducted . A two-way analysis of variance (ANOVA) was used to compare the mean of tear strength of three type of materials and assess the effects of thickness on the tear strength, followed by a Tukey test among groups. The level of significance was set at **$p = 0.05$** for all statistical analysis.

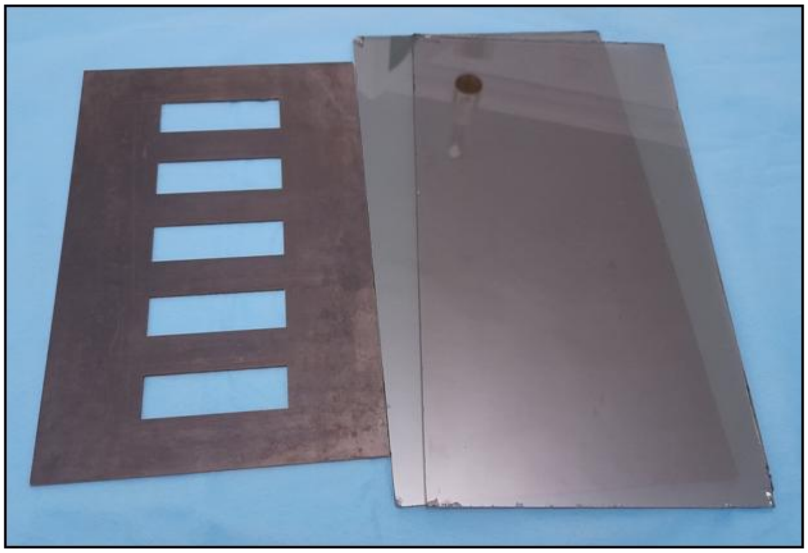

Figure.3.7.metallic mold

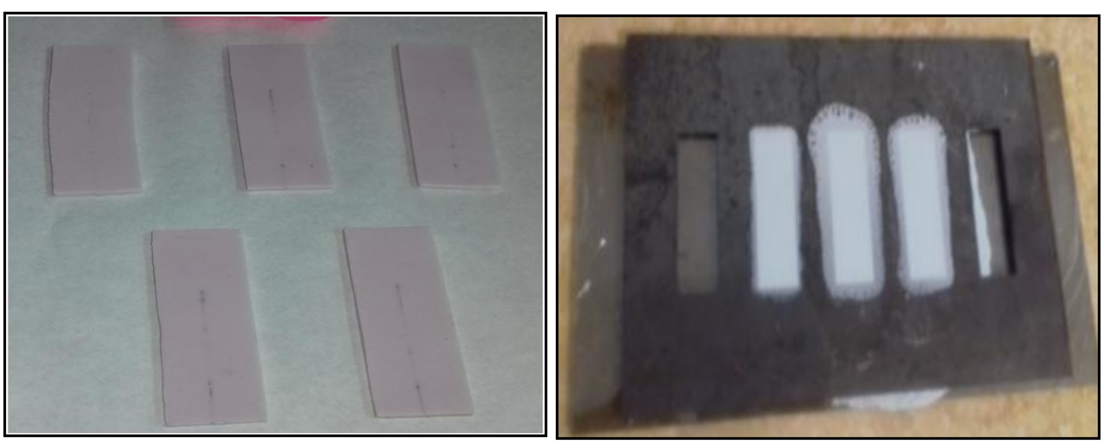

Figure. 3.8. Preparation of the sample

Figure.3.9. Universal Test Machine.

Results

4. Result:

4.1. Dimensional accuracy

4.1.1. Comparison the mean dimensional accuracy of first pour of the alginate and silicone impression materials with repeated pour in six distance

A. First distance (AB):

Table 4.1 and the Figure 4.1 show the mean dimensional accuracy and standard deviation of the first distance of the master casts and repeated pour dental casts obtained from different types of alginate and silicone impression materials .

Table 4.2 shows the result of the two-way ANOVA that compare the mean dimensional accuracy of the first distances for the master casts and repeated dental casts obtained from alginate and silicone impression materials. Two-way ANOVA revealed that there was no statistically significant interaction between the material type and repeated pour on dimensional accuracy, the p-value was (0.206). As well there was no significant different between impression material types where the p-value was (0.721). Also, the repeated pour did not have a statistically significant effect on dimensional accuracy (p= 0.911).

Table 4.1: The means dimensional accuracy and standard deviation of the first distance of master model and repeated pour dental casts obtained from alginate and silicone impression materials.

The impression materials	First distance (AB)			
	First pour		Repeated pour	
	mean	std	mean	std
Conventional	36.250	±0.203	36.211	±0.109
Alginmax	36.191	±0.135	36.217	±0.124
Cavex	36.231	±0.009	36.163	±0.090
Polyvinyl siloxane	36.260	±0.050	36.306	±0.105

Table 4.2. Shows the result of two- way ANOVA

Source of Variation	Sum of Square	Degree of Freedom	Mean Square	F0	P-Value
Materials type	0.0184	3	0.0061	0.4467	0.7213
Pour time	0.0664	1	0.0002	0.0127	0.9111
Interaction	0.4387	3	0.0221	1.6132	0.2057
Error	0.4387	32	0.0137		
Total	0.5236	39			

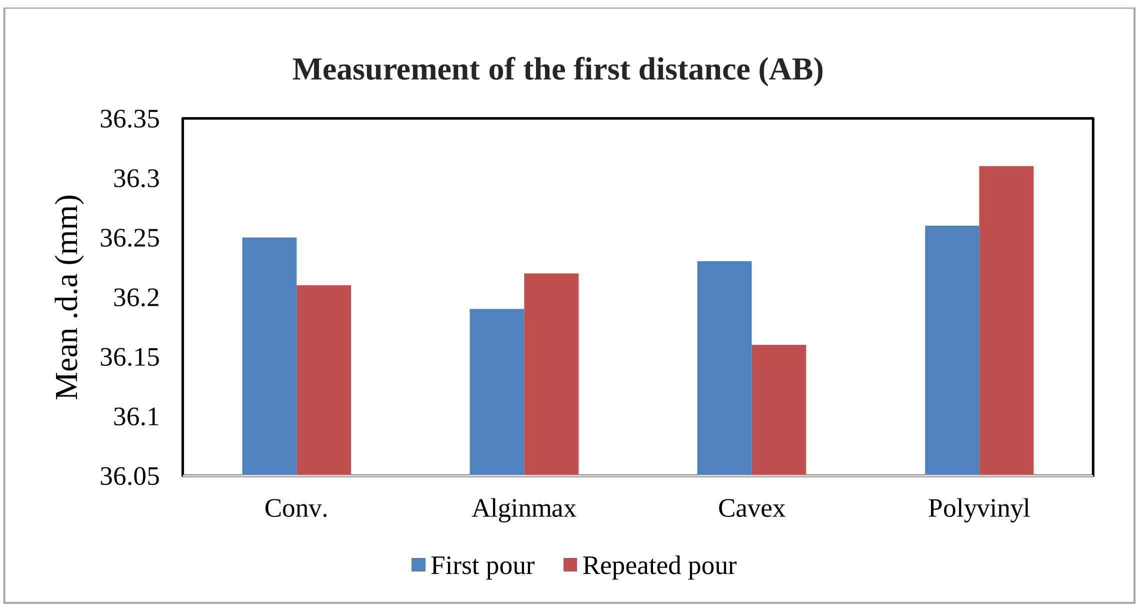

Figure. 4.1. The comparison of the means dimensional accuracy of the first distance of master model and repeated pour dental casts obtained from alginate and silicone impression materials.

B. The second distance (AC):

Table 4.3 and Figure 4.2 show the mean dimensional accuracy and standard deviation of the second distance of master casts and repeated pour dental casts obtained from alginate and silicone impression materials . The two-way (ANOVA) (Table 4.4) was performed to compare the mean dimensional accuracy of second distances for the master casts and repeated dental casts obtained from alginate and silicone impression materials. Two-way ANOVA revealed that there was no statistically significant interaction between the material type and repeated pour on dimensional accuracy, the p-value was (0.274). However, the analysis showed a high significant difference between the impression material types, where the p-value was (0.000). However, the analysis showed that the repeated pour did not have a statistically significant effect on dimensional accuracy (p=0.094).

Table 4.3: The means dimensional accuracy and standard deviation of the second distance of master model and repeated pour dental casts obtained from alginate and silicone impression materials

The impression materials	**Second distance (AC)**			
	First pour		**Repeated pour**	
	mean	std	mean	std
Conventional	35.119	±0.165	34.991	±0.187
Alginmax	34.945	±0.058	34.795	±0.164
Cavex	35.106	±0.097	35.036	±0.127
Polyvinyl siloxane	35.191	±0.104	35.254	±0.073

Table 4.4. Shows the result of two- way ANOVA.

Source of Variation	Sum of Square	Degree of Freedom	Mean Square	F0	P-Value
Materials type	0.6236	3	0.2079	12.2859	0.000
Pour time	0.0504	1	0.0504	2.9795	0.094
Interaction	0.0686	3	0.0229	1.3525	0.2749
Error	0.5414	32	0.0169		
Total	1.284	39			

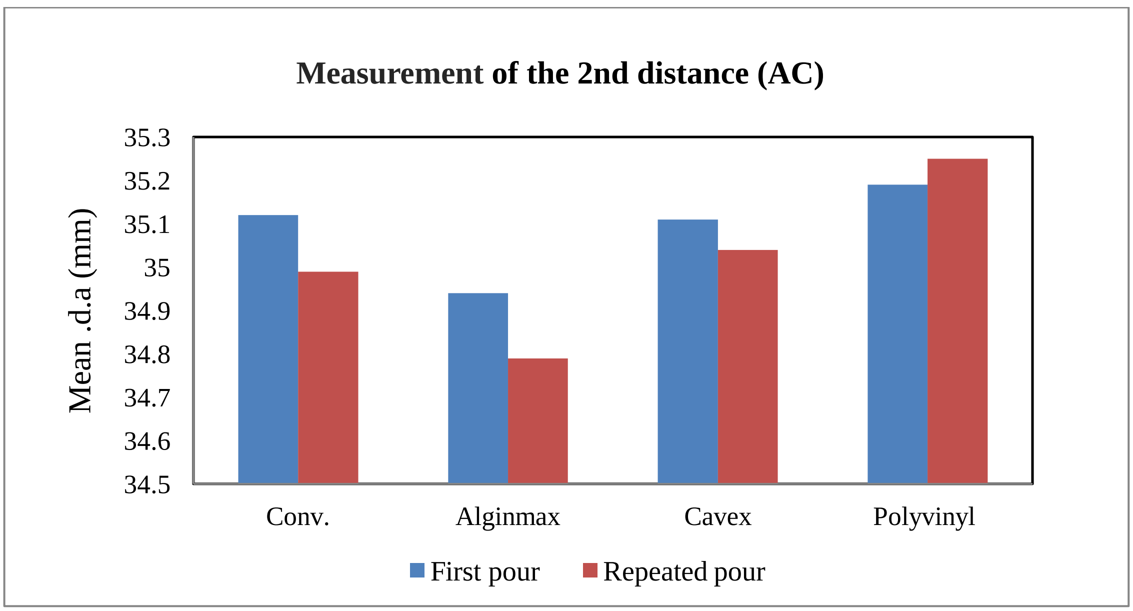

Figure. 4.2. The comparison of the means dimensional accuracy of the second distance of master model and repeated pour dental casts obtained from alginate and silicone impression materials.

C. Third distance (AD):

Table 4.5 and Figure 4.3 show the mean dimensional accuracy and standard deviation of the third distance of master casts and repeated pour dental casts obtained from alginate and silicone impression materials .While Table 4.6 shows the result of the two-way ANOVA . Two-way ANOVA revealed that there was no statistically significant interaction between the material type and repeated pour on dimensional accuracy, where the p-value was (0.1516). However, the analysis showed a significant differences in dimensional accuracy for both the impression material type and the repeated pour, where the p-value were (0.0037) and (0.0402) respectively.

Table 4.5: The means dimensional accuracy and standard deviation of the third distance of master model and repeated pour dental casts obtained from alginate and silicone impression materials

The impression materials	**Third distance (AD)**			
	First pour		**Repeated pour**	
	Mean	Std	Mean	Std
Conventional	31.69334	±0.230	31.39734	±0.281
Alginmax	31.33134	±0.205	31.12666	±0.121
Cavex	31.32	±0.187	31.21266	±0.159
Polyvinyl siloxane	31.318	±0.147	31.40934	±0.141

Table 4.6. Shows the result of two- way ANOVA .

Source of Variation	Sum of Square	Degree of Freedom	Mean Square	F0	P-Value
Materials type	0.5998	3	0.1999	5.4790	0.0037
Pour time	0.1668	1	0.1668	4.5723	0.0402
Interaction	0.2066	3	0.0689	1.8871	0.1516
Error	1.1677	32	0.0365		
Total	2.1409	39			

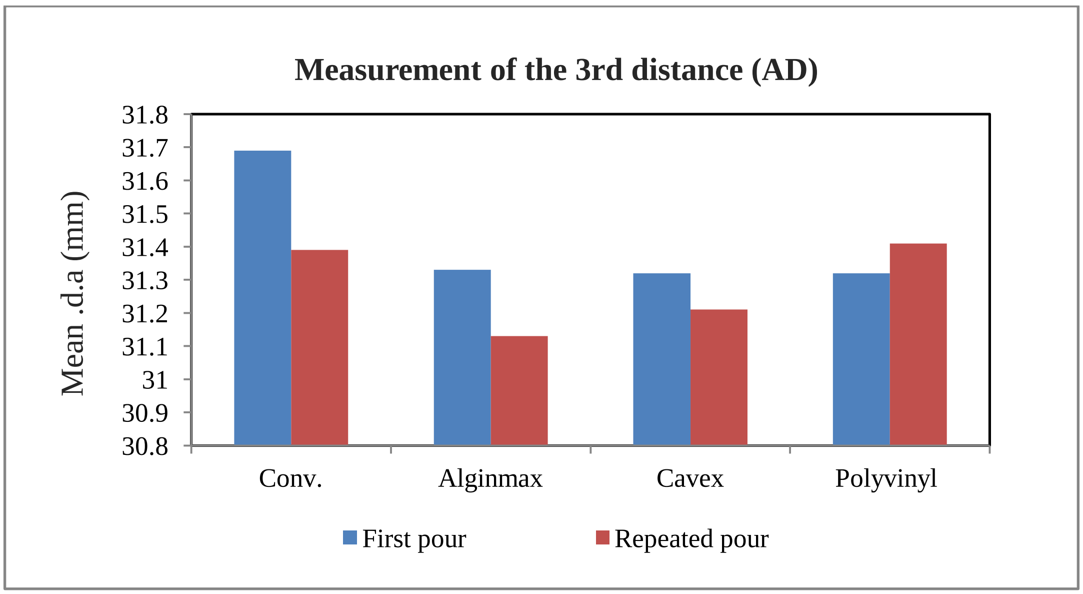

Figure. 4.3. The comparison of the means dimensional accuracy of the third distance of master model and repeated pour dental casts obtained from alginate and silicone impression materials.

D. Fourth distance (BC):

Table 4.7 and the Figure 4.4 the means dimensional accuracy and standard deviation of the fourth distance of master casts and repeated pour dental casts obtained from alginate and silicone impression materials .While table 4.8 shows the result of the two-way ANOVA . Two-way ANOVA revealed that there was no statistically significant interaction between the material type and repeated pour on dimensional accuracy, the p-value was (0.5840).

As well the analysis showed there were insignificant differences in dimensional accuracy for both the impression material type and the repeated pour, where the p-value were (0.6614) and (0.9058) respectively.

Table 4.7: The means dimensional accuracy and standard deviation of the fourth distance of master model and repeated pour dental casts obtained from alginate and silicone impression materials.

The impression materials	**Fourth distance (BC)**			
	First pour		**Repeated pour**	
	Mean	Std	Mean	Std
Conventional	43.144	±0.089	43.2 19	±0.136
Alginmax	43.153	±0.201	43.078	±0.151
Cavex	43.18	±0.176	43.136	±0.184
Polyvinyl siloxane	43.16	±0.134	43.226	±0.044

Table 4.8. Shows the result of two- way ANOVA .

Source of Variation	Sum of Square	Degree of Freedom	Mean Square	F0	P-Value
Materials type	0.0351	3	0.0117	0.5353	0.6614
Pour time	0.0003	1	0.0003	0.0142	0.9058
Interaction	0.0432	3	0.0144	0.6579	0.5840
Error	0.7000	32	0.0219		
Total	0.7786	39			

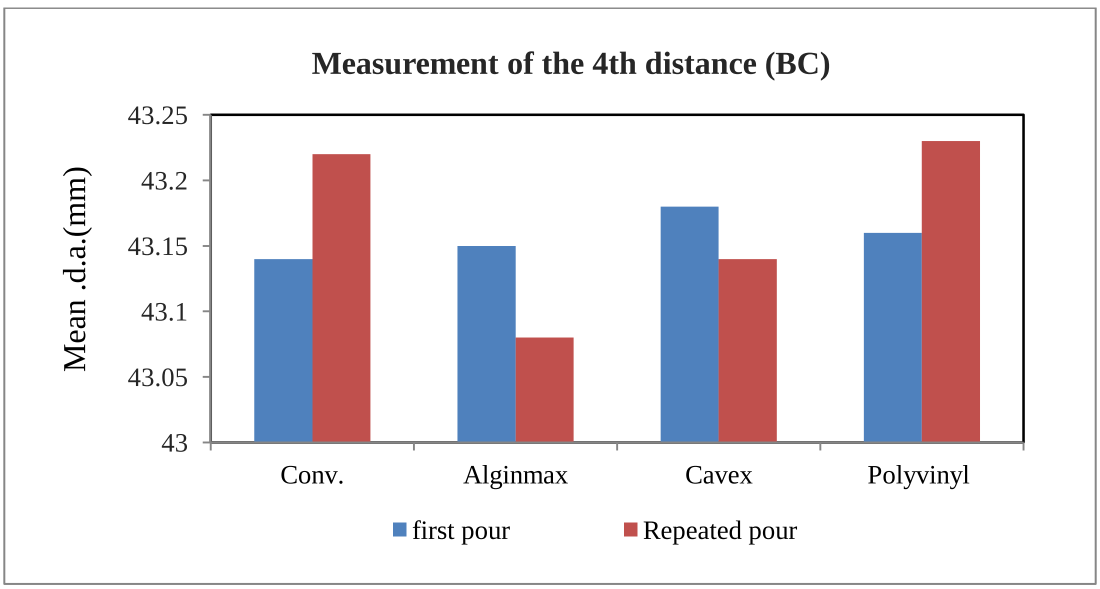

Figure. 4.4. The comparison mean of dimensional accuracy of fourth distance of master model and repeated pour dental casts obtained from alginate and silicone impression materials.

E. Fifth distance (BD):

Table 4.9 and Figure 4.5 shows the mean dimensional accuracy and standard deviation of the fifth distance of master casts and repeated pour dental casts obtained from alginate and silicone impression materials .While Table 4.10 shows the result of the two-way ANOVA . Two-way ANOVA revealed that there was no statistically significant interaction between the material type and repeated pour on dimensional accuracy, where the p-value was (0.4074). The analysis showed that there was a significant difference between the impression materials types, where the p-value was (0.0232).

However, the analysis showed that the repeated pour did not have a statistically significant effect on dimensional accuracy (p=0.3560).

Table 4.9. The means dimensional accuracy and standard deviation of the fifth distance of master model and repeated pour dental casts obtained from alginate and silicone impression materials.

The impression materials	Fifth distance (BD)			
	First pour		Repeated pour	
	Mean	Std	Mean	Std
Conventional	26.139	±0.152	26.051	±0.123
Alginmax	26.292	±0.182	26.157	±0.125
Cavex	26.039	±0.151	26.101	±0.168
Polyvinyl siloxane	26.229	±0.081	26.225	±0.087

Table 4.10. Shows the result of two- way ANOVA .

Source of Variation	Sum of Square	Degree of Freedom	Mean Square	F0	P-Value
Materials type	0.2087	3	0.0696	3.6297	0.0232
Pour time	0.0168	1	0.0168	0.8771	0.3560
Interaction	0.0572	3	0.0191	0.9957	0.4074
Error	0.6132	32	0.0192		
Total	0.8960	39			

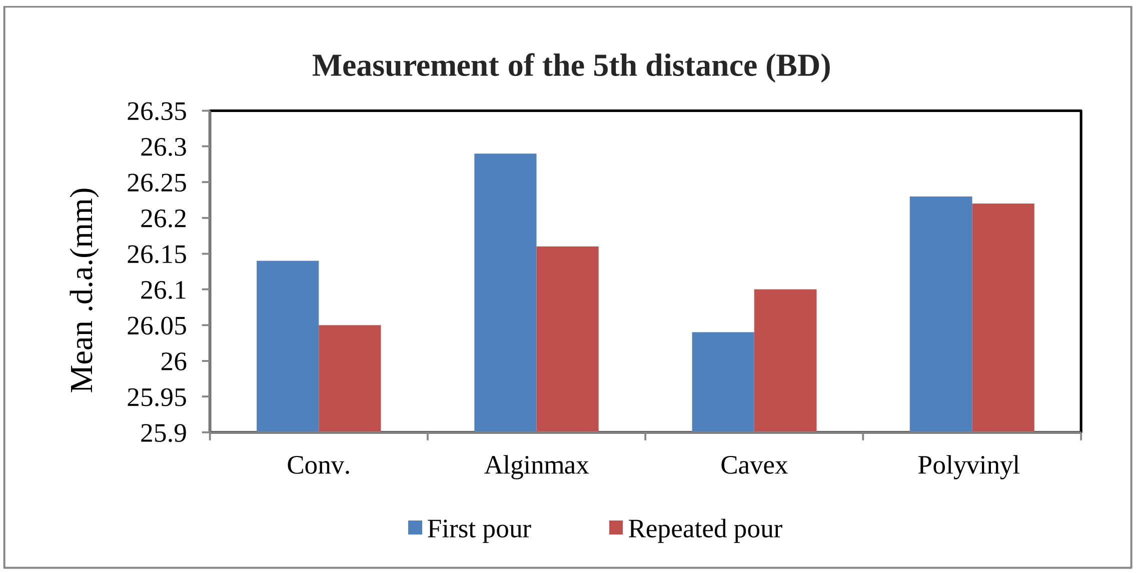

Figure. 4.5. The comparison of the means dimensional accuracy of the fifth distance of master model and repeated pour dental casts obtained from alginate and silicone impression materials.

F. Sixth distance (CD):

Table 4.11 and the Figure 4.6 show the mean dimensional accuracy and standard deviation of the sixth distance of master casts and repeated pour dental casts obtained from alginate and silicone impression materials .While table 4.12 shows the result of the two-way ANOVA . Two-way ANOVA revealed that there was no statistically significant interaction between the material type and repeated pour on dimensional accuracy, where the p-value was (0.1205). The analysis also, showed that there was a significant difference between the impression materials types, where the p-value was (0.0130).

However, the analysis showed that the repeated pour did not have a statistically significant effect on dimensional accuracy (p= 0.6886).

Table 4.11. The means dimensional accuracy and standard deviation of the sixth distance of master model and repeated pour dental casts obtained from alginate and silicone impression materials.

The impression materials	Sixth distance (CD)			
	First pour		Repeated pour	
	Mean	Std	Mean	Std
Conventional	24.98666	±0.204	24.95534	±0.177
Alginmax	25.09	±0.197	24.89534	±0.152
Cavex	25.02532	±0.174	25.00866	±0.114
Polyvinyl siloxane	25.11534	±0.092	25.27666	±0.121

Table 4.12. Show the result of two- way ANOVA.

Source of Variation	Sum of Square	Degree of Freedom	Mean Square	F0	P-Value
Materials type	0.3180	3	0.1060	4.1930	0.0130
Pour time	0.0041	1	0.0041	0.1635	0.6886
Interaction	0.1588	3	0.0529	2.0944	0.1205
Error	0.8089	32	0.0253		
Total	1.2898	39			

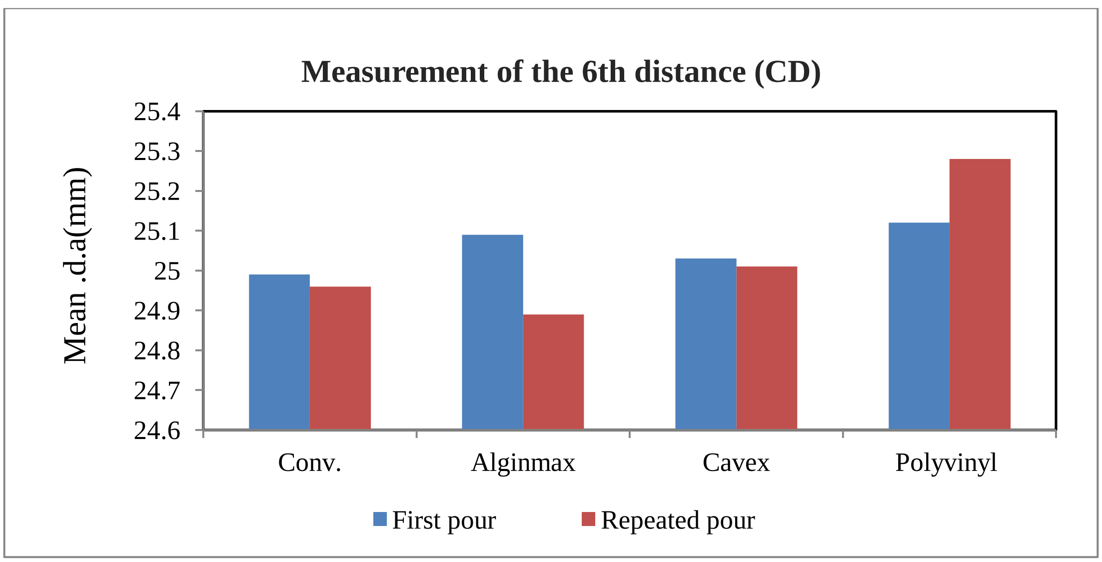

Figure. 4.6.The comparison of the means dimensional accuracy of the sixth distance of master model and repeated pour dental casts obtained from alginate and silicone impression materials.

4.1.2. Comparison of mean dimensional accuracy after delayed pour

A. First distance.

Table 4.13 and Figure 4.7 show the mean dimensional accuracy and standard deviation of the first distance of dental casts obtained from two types of alginate impression materials at different pouring times.

Table 4.14 shows the result of the two-way analysis of variance (ANOVA) that compare the mean dimensional accuracy of the first distances of dental casts obtained from two types of alginate impression materials at different pouring time .Two-way ANOVA revealed that there was no statistically significant interaction between the material type and pouring time on dimensional accuracy, the p-value was (0.2548). However, the analysis showed a significant difference in dimensional accuracy for both the impression material type and the pouring time, where the p- value were (0.0104) and (0.0018) respectively.

Table 4.15 show a comparison between the first distances of alginmax impression material at different pouring times by using the Tukey test. The Tukey was calculated T_{α} ($T_{0.05}$) and the difference between the means of two groups which should be more than T_{α} value to be significant difference and if the difference between the means of the compared groups was less than T_{α} this means there was no significant difference.

Tukey test showed that there was no significant difference between the master cast poured immediately (considered as zero time) and dental casts poured after (1\8 day,3 days,5 days). However, there was a significant difference between the master cast poured at zero time and the cast poured after 9 days. Also, the analysis showed that there was no significant difference between the dental cast that poured after 1/8 day and the dental casts poured after (3 days, 5 days, and 9 days). As well, the dental casts that poured after 3 days revealed insignificant differences when compared with casts poured after 5 days. However, the cast that poured after 3 days showed a significant difference from the dental cast poured after 9 days. Also, the test showed that there was no significant difference between the cast poured after 5 days and that poured after 9 days. While the comparison between the first distances of cavex impression material at different times by using the Tukey test (Table 4.15) showed that there was no significant difference between the measured means.

Table 4.13: the mean dimensional accuracy and standard deviation of the first distance of dental casts obtained from two types of alginate impression materials at different pouring times

The time of pour	1st distance (AB)			
	Alginmax		Cavex color change	
	Mean	Std	Mean	Std
Zero time	36.399	±0.110	36.495	±0.069
1/8 day(3 hours)	36.318	±0.315	36.455	±0.230
3 days	36.468	±0.183	36.403	±0.119
5 days	36.229	±0.186	36.451	±0.164
9 days	36.005	±0.145	36.273	±0.101

Table 4.14: A comparison of the mean dimensional accuracy of the first distances of dental casts obtained from two types of alginate impression materials at different pouring times.

Source of Variation	Sum of Square	Degree of Freedom	Mean Square	F0	P-Value
Materials type	0.2165	1	0.2165	7.2294	0.0104
Pour time	0.6238	4	0.1559	5.2077	0.0018
Interaction	0.1665	4	0.0416	1.3899	0.2548
Error	1.1978	40	0.0299		
Total	2.2045	49			

Table 4.15:The result of Tukey test shows a comparison of 1st distance of dental casts obtained from Alginmax and cavex impression materials at different times.

Tukey test	Alginmax ($T_{0.05}$ =0.3805)				Cavex($T_{0.05}$=0.2655)			
	1/8 day	3 Day	5 Days	9 Days	1/8 day	3 Days	5 Days	9 Days
Zero time	0.0806	0.0686	0.1699	0.3933	0.04	0.092	0.0440	0.2213
1/8 day		0.1493	0.0893	0.3126		0.052	0.0040	0.1813
3 Days			0.2386	0.462			0.048	0.1293
5 Days				0.2233				0.1773
9 Days								

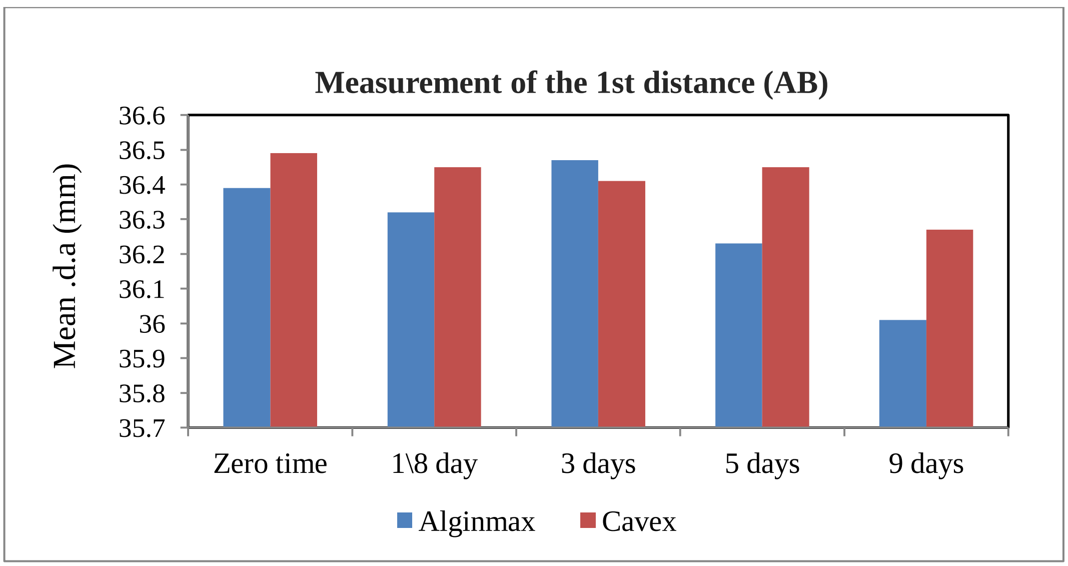

Figure 4.7: Comparison of mean dimensional accuracy of a first distance of dental casts obtained from two types of alginate impression materials at different times.

B. Second distance.

Table 4.16 and Figure 4.8 show the mean dimensional accuracy of the second distance of dental casts obtained from two types of alginate impression materials at different pouring times .

Table 4.17 showed the result of the two-way (ANOVA) that compare the mean dimensional accuracy of the second distances of dental casts obtained from two types of alginate impression materials at different pouring time. Two-way ANOVA revealed that there was no statistically significant interaction between the material type and pouring time on dimensional accuracy, where the p-value was (0.9752). As well the analysis showed that there were no significant differences between impression material types where the p-value was (0.2966). However, the analysis showed that the pouring time did have a statistically significant effect on dimensional accuracy ($p= 0.0005$).

The comparison between the second distances of alginmax impression material at different pouring times by using the Tukey test (Table 4.18) showed that there was no significant difference between the measurements.

Table 4.18 shows a comparison between the second distances of cavex impression material at different pouring times by using the Tukey test . Which showed that there was no significant difference between the master cast poured at zero time and dental casts poured after (1\8 day,3 days,5 days). However, there was a significant difference between the master cast poured at zero time and the cast poured after 9 days. Also, the analysis showed that there was no significant difference between the dental cast that poured after 1/8 day and the dental casts poured after (3 days, 5 days, and 9 days). As well, there was no significant difference between the dental casts that poured after 3 days and casts poured after 5 days and 9 days. Also the analysis showed that there was insignificant difference between the dental casts poured after 5 days and that poured after 9 days.

Table 4.16: The mean dimensional accuracy and standard deviation of 2nd distance of dental casts obtained from two types of alginate impression materials at different pouring times.

The time of pour	2nd distance (AC)			
	alginmax		cavex color change	
	Mean	Std	Mean	Std
zero time	35.233	±0.132	35.313	±0.111
1/8 day	35.075	±0.231	35.079	±0.143
3 days	35.11	±0.179	35.214	±0.205
5days	35.095	±0.256	35.134	±0.190
9days	34.865	±0.141	34.907	±0.148

Table 4.17: Comparison the mean dimensional accuracy of the 2nd distances of dental casts obtained from two types of alginate impression materials at different pouring times.

Source of Variation	Sum of Square	Degree of Freedom	Mean Square	F0	P-Value
Materials type	0.0361	1	0.0361	1.1184	0.2966
Pour time	0.8039	4	0.2010	6.2283	0.0005
Interaction	0.0153	4	0.0038	0.1183	0.9752
Error	1.2908	40	0.0323		
Total	2.1461	49			

Table 4.18:The result of the Tukey test shows a comparison of the 2nd distance of dental casts obtained from alginmax and cavex impression materials at different times.

Tukey test	Alginmax ($T_{0.05}$ =0.3687)				Cavex($T_{0.05}$=0.31001)			
	1/8 day	**3 Day**	**5 Days**	**9 Days**	**1/8 day**	**3 Days**	**5 Days**	**9 Days**
Zero time	0.158	0.1233	0.1380	0.3686	0.2346	0.0993	0.1793	0.406
1/8 day		0.0346	0.02	0.2106		0.1353	0.05534	0.1713
3 Days			0.0146	0.2453			0.08	0.3066
5 Days				0.2306				0.2266
9 Days								

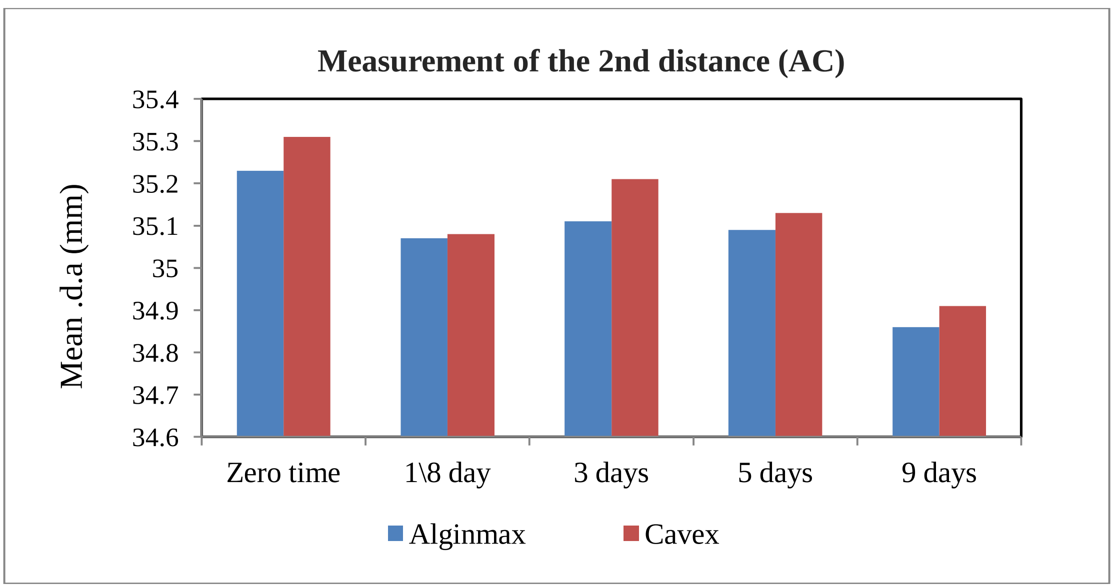

Figure 4.8: Comparison of mean dimensional accuracy of 2nd distance of dental casts obtained from two types of alginate impression materials at different times.

C. Third distance.

Table 4.19 and Figure 4.9 show the mean dimensional accuracy and standard deviation of the third distance of dental casts obtained from two types of alginate impression materials at different pouring times .

Two-way ANOVA (Table 4.20) revealed that there was no a statistically significant interaction between the material type and pouring time on dimensional accuracy, the p-value was (0.1918). As well the analysis showed that there was no significant different between impression material type where the p-value was (0.6978). However, the analysis showed that the pouring time did have a statistically significant effect on dimensional accuracy (p= 0.0175).

The comparison between the third distances of alginmax impression material at different pouring times by using Tukey test (Table 4.21) showed that there was no significant differences between measured means. Also, the comparison between the third distances of cavex impression material at different pouring times by using the Tukey test(Table 4.21) showed that there was no significant differences between the measured means.

Table 4.19: The mean dimensional accuracy and standard deviation of the third distance of dental casts obtained from two types of alginate impression materials at different pouring times.

The time of pour	3rd distance (AD)			
	Alginmax		Cavex color change	
	Mean	Std	Mean	Std
Zero time	31.497	±0.134	31.396	±0.116
1/8 day	31.189	±0.215	31.393	±0.042
3 days	31.409	±0.159	31.359	±0.104
5 days	31.363	±0.207	31.309	±0.135
9 days	31.249	±0.144	31.163	±0.216

Table 4.20: a comparison of the mean dimensional accuracy of 3rd distances of dental casts obtained from two types of alginate impression materials at different pouring times.

Source of Variation	Sum of Square	Degree of Freedom	Mean Square	F0	P-Value
Materials type	0.0038	1	0.0038	0.1529	0.6978
Pour time	0.3336	4	0.0834	3.3958	0.0175
Interaction	0.1577	4	0.0394	1.6054	0.1918
Error	0.9824	40	0.0246		
Total	1.4774	49			

Table 4.21:The result of the Tukey test shows a comparison of the 3rd distance of dental casts obtained from alginmax and cavex impression materials at different times.

Tukey test	Alginmax ($T_{0.05}$ =0.3326)				Cavex($T_{0.05}$=0.2567)			
	1/8 day	3 Day	5 Days	9 Days	1/8 day	3 Days	5 Days	9 Days
Zero time	0.3080	0.0886	0.1346	0.2486	0.0026	0.0373	0.0873	0.2326
1/8 day		0.2193	0.1733	0.0593		0.0346	0.0846	0.2300
3 Days			0.046	0.1599			0.0500	0.1953
5 Days				0.1139				0.1453
9 Days								

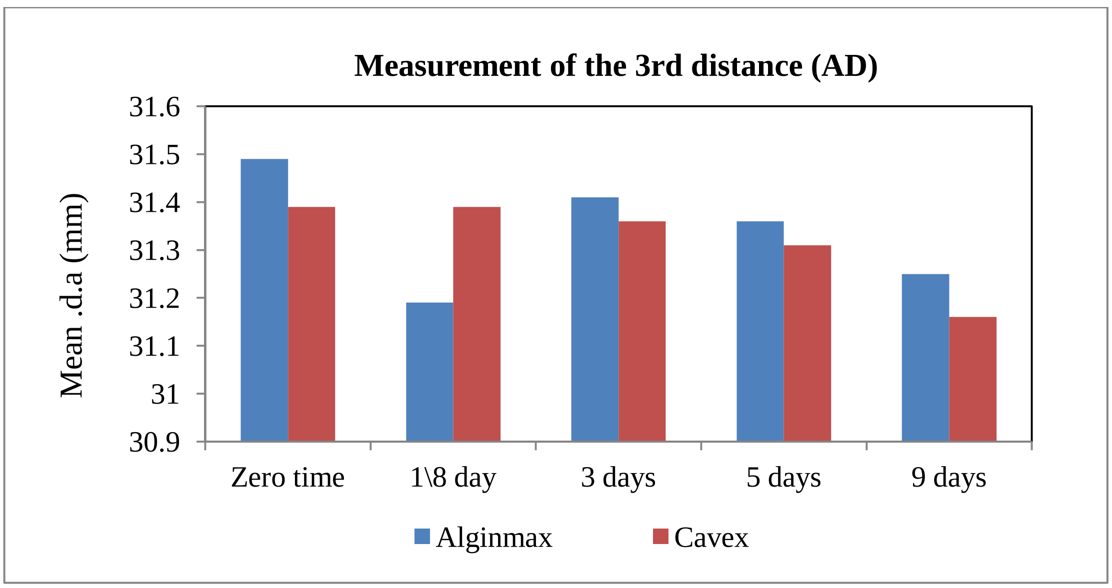

Figure 4.9: Comparison of mean dimensional accuracy of the 3rd distance of dental casts obtained from two types of alginate impression materials at different times

D. Fourth distance.

Table 4.22 and Figure 4.10 show the mean dimensional accuracy and standard deviation of the fourth distance of dental casts obtained from two types of alginate impression materials at different pouring times .

Two-way ANOVA (Table 4.23) revealed that there was no statistically significant interaction between the impression material type and pouring time on dimensional accuracy, Where the p-value was (0.3226). As well, the analysis showed that there were no significant differences between impression materials types where the p-value was (0.1571). However, the analysis shows that the pouring time did have a statistically significant effect on dimensional accuracy (p= 0.0077).

Table 4.24 showed the comparison between the fourth distances of alginmax impression material at different pouring times by using the Tukey test. Which showed that there was no significant difference between the master cast poured at zero time and dental casts poured after (1\8 day,3 days,5 days). However, there was a significant difference between the master cast poured at zero time and the cast poured after 9 days. Also, the analysis showed that there was no significant difference between the dental cast that poured after 1/8 day and the dental casts poured after (3 days, 5 days, and 9 days). As well, there was no significant difference between the dental casts that poured after 3 days and casts poured after 5 days and 9 days. Also the analysis showed that there was insignificant difference between the dental casts poured after 5 days and that poured after 9 days.

While the comparison between the fourth distances of cavex impression material at different times by using the Tukey test(Table 4.24) showed that there were no significant differences between the measurements.

Table 4.22: The mean dimensional accuracy and standard deviation of the fourth distance of dental casts obtained from two types of alginate impression materials at different times.

The time of pour	4th distance (BC)			
	Alginmax		Cavex color change	
	Mean	Std	Mean	Std
Zero time	43.374	±0.056	43.297	±0.079
1/8 day	43.163	±0.136	43.227	±0.119
3 days	43.117	±0.147	43.122	±0.201
5 days	43.167	±0.195	43.288	±0.178
9 days	43.002	±0.178	43.193	±0.123

Table 4.23: a comparison of the mean dimensional accuracy of fourth distances of dental casts obtained from two types of alginate impression materials at different pouring times

Source of Variation	Sum of Square	Degree of Freedom	Mean Square	F0	P-Value
Materials type	0.0462	1	0.0462	2.0791	0.1571
Pour time	0.3589	4	0.0897	4.0367	0.0077
Interaction	0.1074	4	0.0268	1.2076	0.3226
Error	0.8890	40	0.0222		
Total	1.4015	49			

Table 4.24:The result of Tukey test show a comparison of the fourth distance of dental casts obtained from alginmax and cavex impression materials at different pouring times.

Tukey test	Alginmax ($T_{0.05}$=0.2863)				Cavex($T_{0.05}$=0.2789)			
	1/8 Day	**3 Day**	**5 Day**	**9 Days**	**1\8 Day**	**3 Days**	**5 Days**	**9 Days**
zero time	0.2106	0.2566	0.2073	0.3720	0.0693	0.1746	0.0086	0.1033
1/8 Day		0.0459	0.0033	0.1613		0.1053	0.0606	0.3400
3 Day			0.0493	0.1153			0.166	0.0713
5 Day				0.1646				0.0946
9 Days								

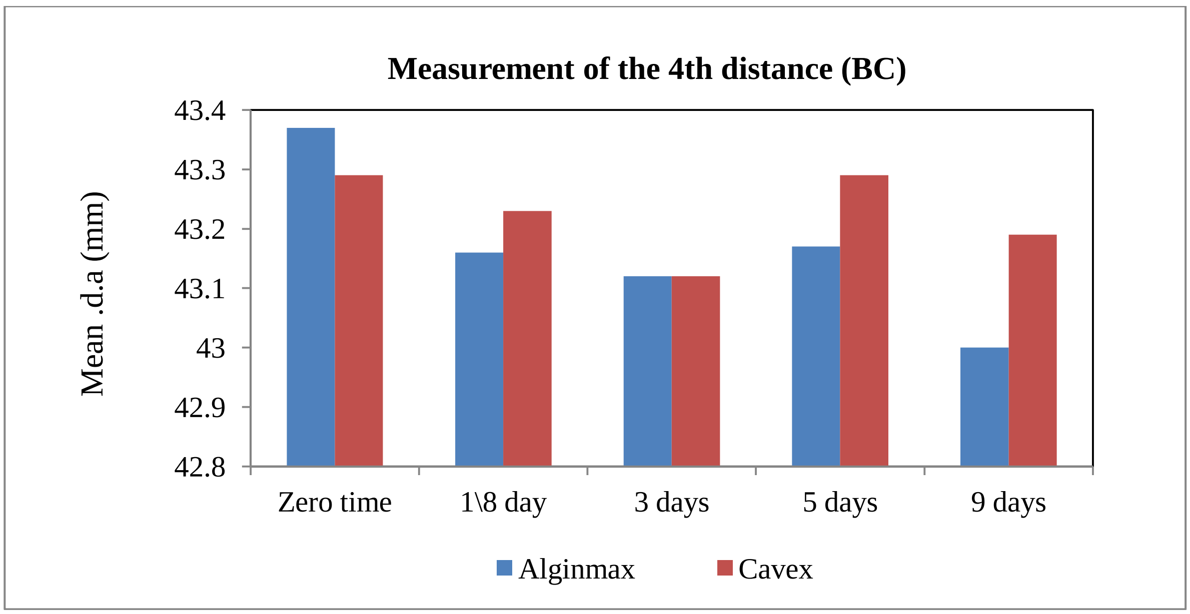

Figure 4.10: Comparison of means dimensional accuracy of the 4th distance of dental casts obtained from two types of alginate impression materials at different times.

E. Fifth distance.

Table 4.25 and Figure 4.11 show the mean dimensional accuracy and standard deviation of the fifth distance of dental casts obtained from two types of alginate impression materials at different pouring times .

Two-way ANOVA (Table 4.26) revealed that there was no statistically significant interaction between the material type and pouring time on dimensional accuracy, where the p-value was (0.6959). As well, the analysis showed that there were no significant differences between impression material types where the p-value was (0.9452). Also, the analysis showed that the pouring time did not have a statistically significant effect on dimensional accuracy (p= 0.3334).

Table 4.27 showed the comparison between the fifth distances of alginmax impression material at different pouring times by using the Tukey test which showed that there was no significant differences between measured means.

Also, the comparison between the fifth distances of cavex impression material at different pouring times by using the Tukey test (4.27) showed that there was no significant difference between the measurements.

Table 4.25: The mean dimensional accuracy and standard deviation of the fifth distance of dental casts obtained from two types of alginate impression materials at different times.

The time of pour	5th distance (BD)	
	Alginmax	Cavex color change
Zero time	26.188 ±0.087	26.195 ±0.172
1/8 day	26.111 ±0.126	26.005 ±0.098
3 days	26.165 ±0.127	26.134 ±0.180
5 days	26.066 ±0.213	26.081 ±0.153
9 days	25.98 ±0.340	26.113 ±0.202

Table 4.26: a comparison of the mean dimensional accuracy of the 5th distances of dental casts obtained from two types of alginate impression materials at different pouring times

Source of Variation	Sum of Square	Degree of Freedom	Mean Square	F0	P-Value
Materials type	0.0002	1	0.0002	0.0048	0.9452
Pour time	0.1601	4	0.0400	1.1819	0.3334
Interaction	0.0753	4	0.0188	0.5559	0.6959
Error	1.3542	40	0.0339		
Total	1.5897	49			

Table 4.27:The result of Tukey test show a comparison of the fifth distance of dental casts obtained from alginmax and cavex impression materials at different pouring times.

Tukey test	Alginmax ($T_{0.05}$=0.3806)				Cavex($T_{0.05}$=0.3139)			
	1/8 Day	**3 Day**	**5 Day**	**9 Days**	**1\8 Day**	**3 Days**	**5 Days**	**9 Days**
zero time	0.0773	0.0226	0.1220	0.2080	0.1893	0.0613	0.1133	0.0813
1/8 Day		0.0546	0.0446	0.1306		0.128	0.076	0.108
3 Day			0.0993	0.1853			0.052	0.0200
5 Day				0.0860				0.032
9 Days								

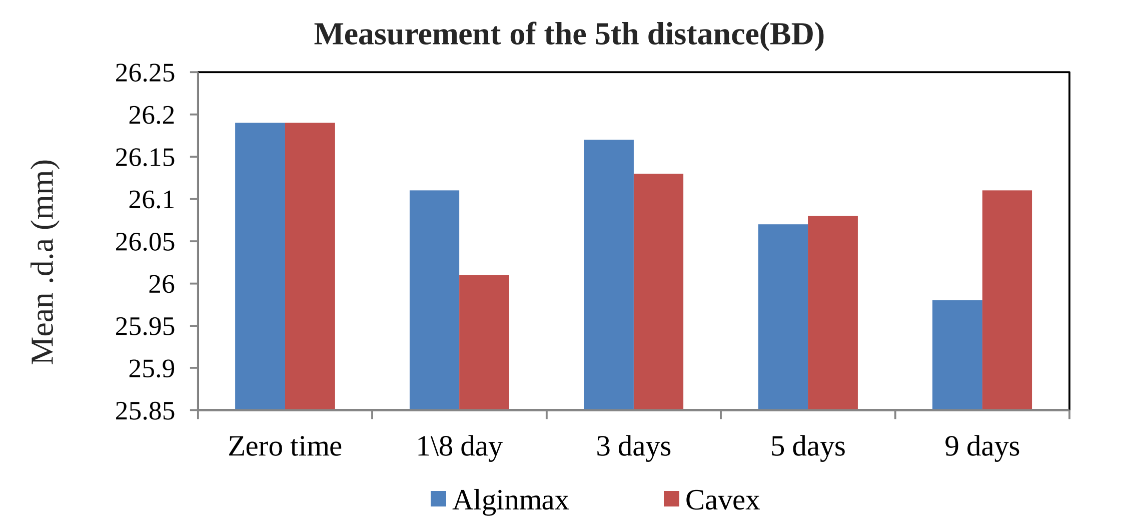

Figure 4.11: Comparison of mean dimensional accuracy of 5th distance of dental casts obtained from two types of alginate impression materials at different pouring times.

F. Sixth distance.

Table 4.28 and Figure 4.12 show the mean dimensional accuracy and standard deviation of the sixth distance of dental casts obtained from two types of alginate impression materials at different pouring times .

Two-way ANOVA (Table 4.29) revealed that there was a statistically significant interaction between the material type and pouring time on dimensional accuracy, where the p-value was (0.0176). However, the analysis showed that there were no significant differences between the impression material types where the p-value was (0.2644). Also, the analysis showed that pouring time did not have a statistically significant effect on dimensional accuracy (p= 0.1999).

Table 4.30 showed the comparison between the sixth distances of alginmax impression material at different pouring times by using the Tukey test . Which showed that there was no significant difference between the master cast poured at zero time and dental casts poured after (1\8 day,3 days,5 days). However, there was a significant difference between the master cast poured at zero time and the cast poured after 9 days. Also, the analysis showed that there was no significant difference between the dental cast that poured after 1/8 day and the dental casts poured after (3 days, 5 days, and 9 days). As well, the dental casts that poured after 3 days revealed insignificant differences when compared with casts poured after 5 days. However, the cast that poured after 3 days showed a significant difference from the dental cast poured after 9 days. Also, the test showed that there was no significant difference between the cast poured after 5 days and that poured after 9 days

While the comparison among the sixth distances of cavex impression material at different pouring times through the use of the Tukey test (Table 4.30) revealed that there were no significant differences among the measured means.

Table 4.28: The mean dimensional accuracy and standard deviation of 6th distance of dental casts obtained from two types of alginate impression materials at different pouring times.

The time of pour	6th distance (CD)	
	Alginmax	**Cavex color change**
Zero time	25.111 ±0.103	25.123 ±0.107
1/8 day	24.986 ±0.180	25.04 ±0.092
3 days	25.191 ±0.040	24.99 ±0.223
5 days	24.999 ±0.085	25.083 ±0.251
9 days	24.822 ±0.077	25.113 ±0.189

Table **4.29:** A comparison of the mean dimensional accuracy of 6th distances of dental casts obtained from two types of alginate impression materials at different pouring times.

Source of Variation	Sum of Square	Degree of Freedom	Mean Square	F0	P-Value
Materials type	0.0291	1	0.0291	1.2813	0.2644
Pour time	0.1431	4	0.0358	1.5739	0.1999
Interaction	0.3084	4	0.0771	3.3921	0.0176
Error	0.9091	40	0.0227		
Total	1.3897	49			

Table 4.30:Result of Tukey test show a comparison of 6th distance of dental casts obtained from alginmax and cavex impression materials at different times.

Alginmex	Alginmax ($T_{0.05}$=00.2049)				Cavex(T0.05=0.3484)			
	1/8 day	3 Days	5 Days	9 Days	1/8 day	3 Days	5 Days	9 Days
Zero time	0.1246	0.08	0.1120	0.2886	0.0833	0.1333	0.0400	0.0106
1/8 day		0.20467	0.0126	0.1639		0.0499	0.0433	0.0726
3 Day			0.1920	0.3686			0.0933	0.1226
5 Day				0.1766				0.0293
9 Days								

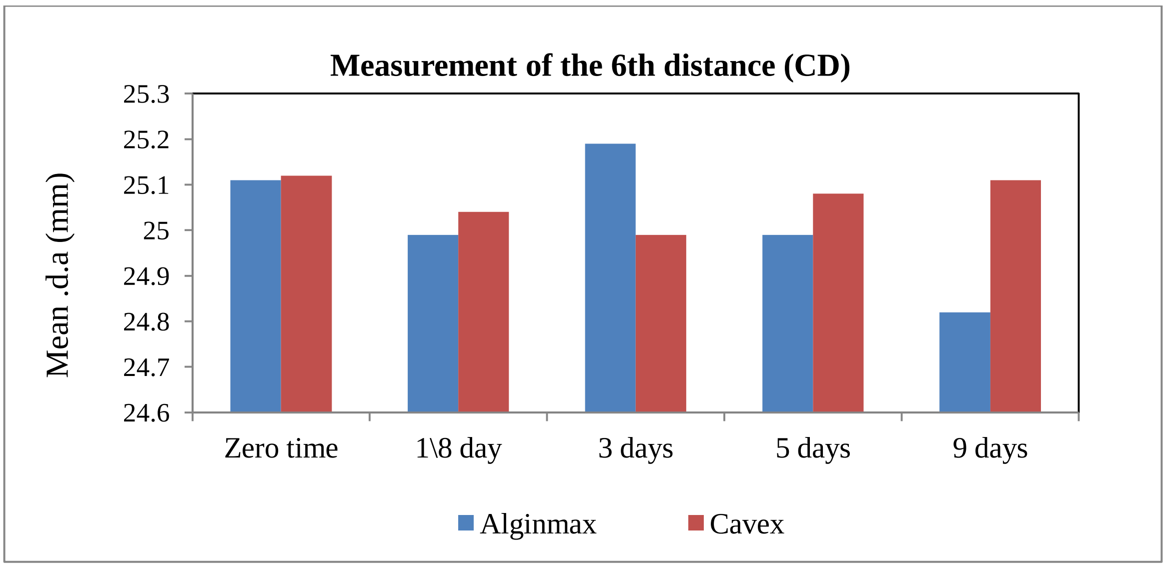

Figure 4.12: Comparison of mean dimensional accuracy of 6th distance of dental casts obtained from two types of alginate impression materials at different times.

4.2. Tear strength

4.2.1. Effect the thickness of impression material on tear strength.

Table 4.31 and the Figure 4.13 show the mean and standard deviation of tear strength for impression materials (Conventional, Alginmax, and Cavex) at different thickness. Two-way analysis of variance (ANOVA) was performed to analyze the effect of thickness on the tear strength for different type of alginate impression materials was shown in Table 4.32.

The two –way ANOVA analysis of variance at 95% confidence level revealed that there was no a statistically significant interaction between the materials type (Conventional, Alginmax, Cavex) and different thicknesses where the **p**-value was (0.9903) .Whereas, the analysis showed that, there was a significant different between the mean values of tested materials (p= 0.0000); this indicated that some of tested groups or all of them have a different affect on the tear strength (this was explored using the Tukey test) as well as, the different thicknesses has not different effects according to their values (p= 0.2104).

The Tukey test was used to compare the mean value of tear strength of each impression materials at different thicknesses. In order to achieve the Tukey test the one way analysis of variance was analyzed. The One-way analysis of the variance test showed that ,there was no a significant differences between three different thicknesses (2mm, 3mm, 4mm) of alginmax impression material, the p-value was (0.969) between them. The Tukey test(Table 4.33) was used which showed there was no significant difference between all groups (G1, G2,and G3).

For cavex impression material, the One-way ANOVA test showed that, there was no a significant difference between different thicknesses, the p-value was (0.611).Comparing the three groups of a thickness of cavex material showed there was no a significant difference between them . In the same way, the one-way ANOVA test showed there were no significant differences between different thicknesses of conventional impression material, where the p-value was (0.516).

Table 4.31: The mean and standard deviation of tear strength for impression materials at different thickness.

Impression material	Means and standard deviation of tear strength of impression materials		
	G 1 :2mm	**G 2 :3mm**	**G 3 :4mm**
Conventional	0.580 ±0.083	0.614 ±0.031	0.620 ±0.044
Cavex	0.480 ±0.044	0.494 ±0.032	0.500 ± 0
Alginmax	0.560 ±0.054	0.586 ±0.058	0.590 ±0.041

Table.4.32:Two way (ANOVA) analysis.

Source of Variation	Sum of Square	Degree of Freedom	Mean Square	F0	P-Value
Materials type	0.1057	2	0.0529	22.4021	0.0000
Thickness	0.0077	2	0.0038	1.6281	0.2104
Interaction	0.0007	4	0.0002	0.0716	0.9903
Error	0.0850	36	0.0024		
Total	0.1991	44			

Table.4.33 :Shows the comparison of mean value of tear strength of each impression materials at different thicknesses.

Different thicknesses	**Impression materials**		
	Conventional ($T_{0.05}$=0.095)	**Cavex ($T_{0.05}$=0.053)**	**Alginmex $T_{0.05}$=0.105)**
G1 with G2	0.034	0.014	0.006
G1 with G3	0.04	0.02	0.01
G2 with G3	0.006	0.006	0.004

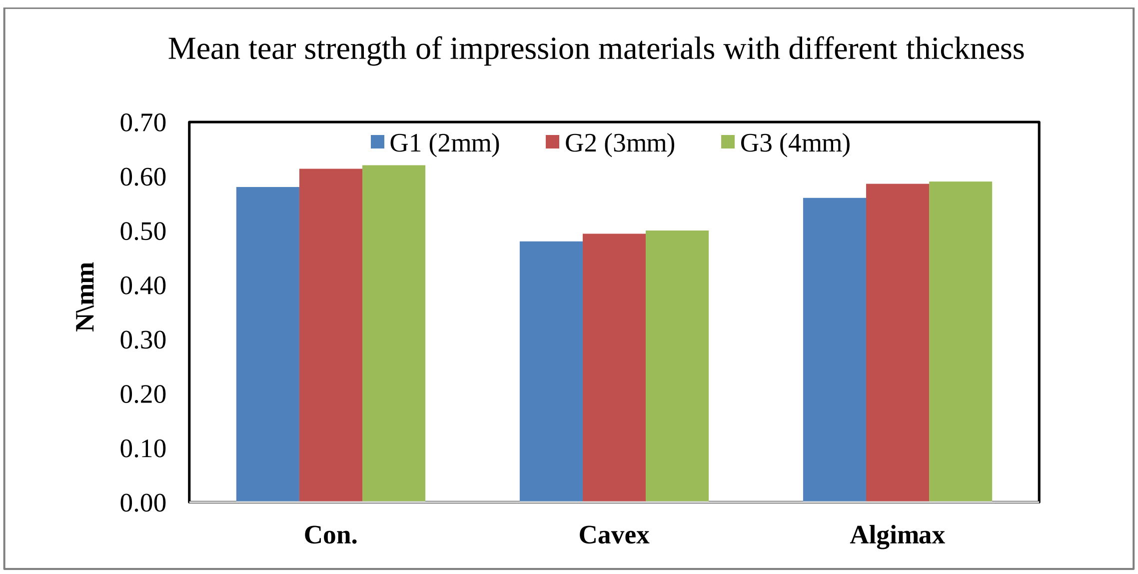

Figure 4.13: The mean tear strength of impression material at different thickness.

4.2.2. Comparison the mean tear strength between alginate impression materials (Conventional ,Cavex and Alginmax) at different thickness.

Table 4.34 shows a comparison between alginate impression materials at different thicknesses by using the Tukey test. Which showed a significant difference between alginmax and cavex impression materials at a thicknesses (3 mm,and4 mm). While the difference at thicknesses (2 mm)was insignificant . Furthermore, the difference between cavex and conventional impression materials was significant for both thickness types (3 mm, and 4 mm) but the difference was insignificant at 2 mm . In contrast, the difference between alginmax and conventional type was insignificant at all different thicknesses.

Figure 4.14 shows the comparison of the mean tear strength between alginate impression materials at different thickness .

Table 4.34: Shows the comparison between different impression materials at different thicknesses by using the Tukey test.

Impression materials	Tukey test		
	2mm ($T_{0.05}$=0.104)	**3mm** ($T_{0.05}$=0.070)	**4mm** ($T_{0.05}$=0.058)
alginmax with cavex	0.08	0.092	0.09
alginmax with conventional	0.02	0.028	0.03
cavex with conventional	0.1	0.12	0.12

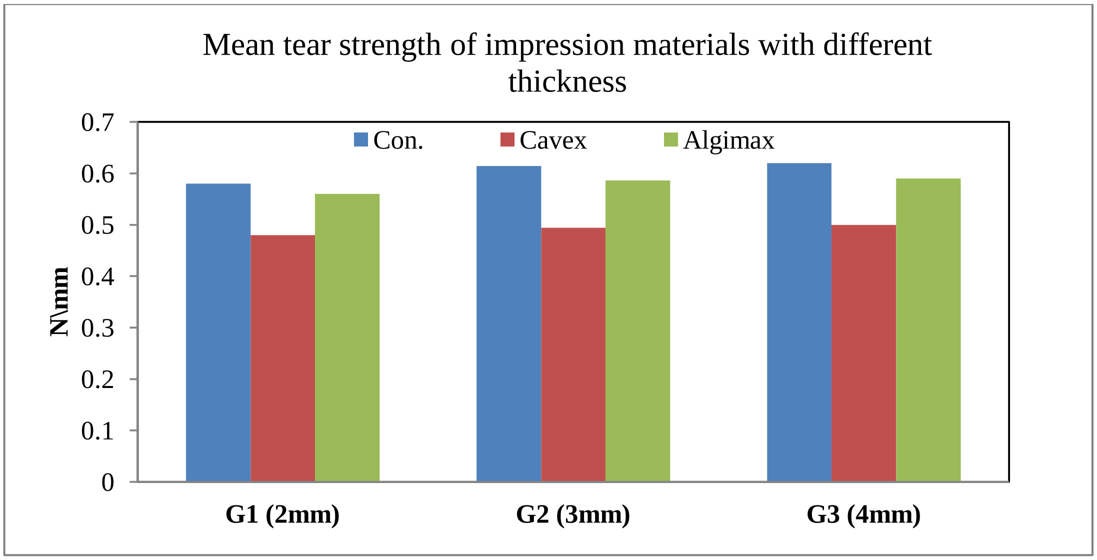

Figure 4.14: Comparison the mean tear strength of alginate impression materials (conventional, cavex, alginmax) at different thickness

Discussion

5.Discussion:

Alginate impression is popular and commonly used impression materials in dental clinic because non toxic non irritant ,its low cost, easy manipulation ,high accuracy ,and comfortable to the patient. Dimensional stability and accuracy of the impression are taken into consideration to be the most important factors because they directly affect the fabrication of prosthesis. (Thomas et al.,2016).

ADA specification number 18 does not specify a specific allowable threshold value for the dimensional change of alginate impression materials. Generally, the dimensional stability of alginate impression may be influenced by internal and external factors. One of the internal factor is the composition of alginate impression material, and the external factors are the storage time and storage procedures.(Craig et al.,2008;Van Noort, 2013)The dimensional accuracy of casts produced from alginates also is influenced by factors other than syneresis, evaporation, imbibition and proprietary constituents controlled by the manufacturer.

PVS materials possess ideal dimensional stability, Because there is no by-product during the chemical setting reaction of addition silicones, They may be poured at the convenience of the operator and are the impression material of choice if the impression is to be sent to the laboratory where the dentist loses control of when it is poured. (Donovan , Chee ,2004)

Random errors may arise from many sources when a clinician makes an impression and generates a gypsum cast. Such sources include incorrect ratios of gypsum powder to water, alginate unsupported by the tray, movement of the tray during gelation, alginate debonding from the tray, incorrect removal of the tray from the mouth and prolonged contact of the alginate with the gypsum product.(Imbery et al.,2010)

The capability of impression materials to produce accurate and dimensionally stable casts generated from repeated pour of a single impression is of great importance for both dentists and dental technicians.(Sayed et al.,2021). So in current study we evaluated the dimensional accuracy of alginate impression materials that undergoes to repeated pour because of clinical importance to the dentist which wants to have two or more casts of the same impression and to avoid problems associated with repeating the impression and the high cost of addition silicone. The recently new product of alginate were introduced to the market reveals that five days stability. Therefore, the current study conducted to evaluate their stability of recommended stability period by the manufacturer.

The analysis of repeated pouring showed that the repeated pour did not have a statistically significant effect on dimensional accuracy of the first distance (p=0.9111), and the percentage dimensional change for (conventional ,alginmax, cavex ,and addition silicone) were (0,009%,0.07%, 0.36%, 0.25%) respectively. This percentage was clinically acceptable as reported by Alcan et al,2009 who considered the percentage of dimensional change ranging from 0.48% to 0.90% to be clinically acceptable. This was because as the change within this range was very small in terms of millimeters .(Alcan et al., 2009)

The second distance showed no significant difference (p=0.094) with percentage of dimensional change for (conventional, alginmax, cavex and addition silicone) were (0.36%, 0.42%, 0.19%, 0.17%). However, the third distance showed a significant difference (p=0.0402) were the percentage of dimensional accuracy (0.93%, 0.65%, 0.34%, 0.29%) (for conventional ,alginmax, cavex ,and addition silicone) impression materials. It can be seen that addition silicone showed less dimensional change followed by cavex, alginmax, while the conventional samples revealed the high percentage of changes. This is may be due to the composition of each material which influence the accuracy of impression materials. The high percentage dimensional change in conventional materials it means there was decrease in the distance that may be attributed to increase the weight of alginate initially to maximum and then decrease. which means alginate takes the water firstly, then give them to outside. Alginate expanded by external liquid then contracted by reversed thermodynamic potential. By utilizing the similar threshold change as chosen by Alcan et al, the values of dimensional change in our study fell within this range.

The analysis showed that repeated pour did not have a statistically significant effect on dimensional accuracy the fourth distance (p=0.9058). The mean percentage dimensional change were (0.17%, 0.17%, 0.1%, 0.15%) for (conventional, alginmax, cavex ,and addition silicone, respectively). As well the analysis showed that repeated pour did not have a statistically significant effect on dimensional accuracy of the fifth distance (p=0.3560).where the mean percentage dimensional change were (0.33%, 0.51%, 0.23%, 0.01%) for (conventional, alginmax, cavex and addition silicone, respectively). Also, the analysis showed that repeated pour did not have a statistically significant effect on dimensional accuracy of the sixth distance (p= 0.6886).where the mean percentage dimensional change were (0.12%, 0.77%, 0.12%, 0.64%) for (conventional, alginmax, cavex, and addition silicone, respectively). It can be seen that the addition silicones showed less dimensional change as they are not sensitive to changes in humidity and do not undergo further chemical reactions or by-product release.(Surapaneni et al.,2013)

ADA Specification No. 19 recommends a maximum allowable dimensional change for elastomeric impression materials to be 0.5% after 24 h (ADA Specification NO 19 ,1977)The dimensions of a cast from the second pour can be affected by continuing polymerization of the impression material and/or by distortion of the impression during removal of the first cast. The addition silicone and condensation silicone products demonstrated the best recovery from undercuts and the least change in dimensions between an initial and second pour of an impression when compared the four types of elastomeric impression materials as a function of model location, time of pouring, and repetition of pouring, moreover, the addition silicone and polyether were the least affected with delays of 1, 4, and 24 hours in pouring the impression as reported by Johnson and Craig. (Johnson , Craig ,1985)

The dimensional accuracy of generated casts from additional silicone impressions after repeat pours at the five different times found to be statistically insignificant different on the accuracy of the generated casts as conformed by previous study.(Mehta et al.,2014)The dimensions of subsequent casts on repeat pouring may be affected by the process of polymerization which involves cross linking of the polymer chains resulting in the reduction of spatial volume. (Marcinak , Draughn ,1982) . The temperature also alters the dimensions both during the setting phase and after the clinical set. The material used to fabricate the replica or working cast may also be a subject to change in dimensions such as gypsum expansion with setting. (Wadhwani et al.,2005)

The current study reveal that repeated pouring of addition silicone did not affect their dimensional stability after repeat pouring, this finding was in agreement with previous studies (Tjan et al.,1986, Ali et al.,2010 and Mehta et al.,2014) where found that the repouring and delayed pouring of the rubber base impressions did not affect their dimensional accuracy and stability. As well the addition silicone impression material found to be preferred material in the field of prosthodontics for repeated pouring up-to 7 days due to its favorable qualities like dimensional accuracy and stability, elastic recovery from undercuts, low creep and moderate to high tear resistance.(Pritam, Mall,2020)

Comparison of the first distance of impression materials with master cast poured at zero time showed statistically significant difference between the master cast poured at zero time and dental casts poured after 9 days of alginmax impression While there was no statistically significant difference with other time(1\8 day,3 days,5 days).While the comparison showed statistically insignificant difference between the master cast poured at zero time and the dental cast poured at all time of cavex impression materials (1\8 day,3 days,5 days,9 days).Also the dimensional percentage change were (0.22,0.18,0.46,1.08%) for alginmex and (0.1,0.25,0.12,0.6%) for cavex material of different pouring time(1\8 day,3day,5 days,9 days) respectively.

Comparison of the second distance of impression materials with master cast poured at zero time showed statistically insignificant difference between the master cast poured at zero time and dental casts poured at all other pouring time of alginmax impression (1\8 day,3 days,5 days,9 days). While the comparison showed statistically significant difference between the master cast poured at zero time and the dental cast poured after 9 days of cavex impression materials. While there was no statistically significant difference with other time (1\8 day, 3days, 5days). Also the dimensional percentages change were (0.35, 0.39, 0.44, 1.04%) for alginmax and ranged between (0.66, 0.28, 0.5, 1.14%) for cavex material. By utilizing the similar threshold change as chosen by Alcan et al, the values of dimensional change in our study for alginmax impression after five days not fell within this range. The decrease in the distance that may be attributed to increase the weight of alginate initially to maximum and then decrease, it means alginate takes the water firstly ,then give them to outside. Alginate expanded by external liquid then contracted by reversed thermodynamic potential.

Whereas the comparison of both third and fifth distance of impression materials with master cast poured at zero time showed statistically insignificant difference between the master cast poured at zero time and dental casts poured at all other pouring time(1\8 day,3 days,5 days,9 days) of alginmax and cavex impression materials . The dimensional percentage change of the third distance were (0.97,0.28,0.42,0.78%) for alginmax and ranged between (0.008,0.11,0.27,0.74%) for cavex material. While the dimensional percentage change of the fifth distance were (0.29,0.08,0.46,0.79%) for alginmax and ranged between (0.72,0.23,0.43,0.31%) for cavex material.

The comparison of the both fourth and sixth distance of impression materials with master cast poured at zero time showed statistically significant difference between the master cast poured at zero time and dental casts poured after 9 days of alginmax impression While there was no statistically significant difference with other time(1\8 day,3 days,5 days).While the comparison showed statistically insignificant difference between the master cast poured at zero time and the dental cast poured at all time of cavex impression materials. The dimensional percentage change of the fourth distance were (0.48,0.59,0.47,0.85%) for alginmax and ranged between (0.16,0.4,0.02,0.23%) for cavex material. While the dimensional percentage change of the sixth distance were (0.49,0.31,0.44,1.14%) for alginmax and ranged between (0.33,0.53,0.15,0.04%) for cavex material.

Alcan ,et al (2009) stored the impressions of different alginates for up to 96 hours at room temperature before pouring them to produce plaster casts. Each plaster cast was then compared with the master model to determine the amount of change. They found that 2 of the 3 alginates studied had statistically dimensional changes over the study period. The percentages of dimensional changes at 96 hours ranged from 0,48% to 0.9% . the authors concluded that because the mean distortion found was “very small in terms of millimeters, the difference can be accepted in clinical tolerance and in orthodontic analyses.(Alcan et al.,2009)

The findings of the current study were supported by other studies. Imbery et al (2010) reported that casts produced from conventional and extended pour alginate immediately and at day 5 had no statistically significant difference with the standard model. As well the Gu¨mu¨s et al (2014) found that all of the conventional and extended pour impression materials tested in their study which poured up to 24 hours with accuracy, if impressions are correctly stored. Extended pour impression materials (Color Change, Hydrogum-5, and Hydro color-5) can be poured up to 120 hours, if stored correctly. Gu¨mu¨s et al.,2014)

However, there was some studies not in agreement with the result present of study, such as Aalaei et al. (2016) were found that there was effect of storage period (12min, 24hr and 120hr) on dimensional stability of alginplus and hydrogum-5, they reported that alginplus and hydrogum -5 impressions were dimensionally stable for at least 24hr. (Aalaei et al.,2016).This may be due to different of material composition and the ratio of ingredients in each products from different manufacturers.

Fellows and Thomas (2009) proposed that alginates with a higher ratio of calcium to sodium lose water more rapidly than do alginates with a lower ratio of calcium to sodium even though they exhibit greater dimensional stability. In addition, these authors observed improved dimensional stability with alginates that contain higher ratios of filler to alginic polymer and lower-weight molecular polymer chains.(Fellows, Thomas ,2009)

Fellow and Thomas in their study suggested that extended-pour alginates exhibit better dimensional stability due to the different chemical composition compared to conventional alginates, this in agreement with current study. Where found that extended-pour alginates have a higher filler: Alginate ratio and Ca: Na ratio. There is a decreased level of soluble alginate which leads to a lower alteration in stability as a lower weight percentage of gel is invariably subject to fewer changes in dimension. Nehring et al(2018) concluded that casts obtained after double pouring of a new generation extended pour alginate were accurate.(Nehring et al.,2018) As well the current study was in agreement with Mosharraf and Mokhtari, who revealed that casts produced from Alginoplast alginate impressions stored for up to 3 hours in a humid environment did not have significant dimensional changes.(Mosharraf ,Mokhtari ,2006)

On the other hand, our finding was in contrast with Todd et al, who demonstrated in their study that all the tested alginates showed significant dimensional changes at 24 and 100 hours. (Todd et al.,2013) This finding regarding the extended pour alginate impression is different from our obtained result, where the author storage the alginate impression samples in different ambient temperature, where current study the storage temperature was at room temperature which may be the reason for different results obtained.

Sayed et al (2021) Concluded that the dimensional stability of different alginate materials vary with thickness, storage time, and multiple pouring in both conventional and extended pour alginates. Shorter storage time and greater thickness of the impression material are preferred when the same impression has to be poured twice. (Sayed et al.,2021)

In a previous study done by Haywood et al (1998) suggested that when alginate impressions are kept moist by completely wrapping in a damp paper towel during stone setting and poured within 45 min, two diagnostic casts could be generated from one impression with the same degree of accuracy.(Haywood et al.,1998) In addition Choudhary et al (2018) concluded that multiple casts can be produced from a single impression with acceptable accuracy, compared to the casts obtained with different impressions. (Choudhary et al.,2018).

5.2.Tear strength.

In this study we measured tear strength of alginate materials because important of tear energy property when using alginate impression in area where the impression lack the bulk or encounter undercut. It is very critical that alginate has sufficient strength in order to do not tear upon removal from the mouth. Factors that contribute to alginate gel strength are 1. P/W ratio, 2. mixing time, 3. time of elimination from the mouth, and 4. rate of removal from the mouth. Clinically, the initial set of alginate is determined by a lack of surface tackiness.(Fayaz, Noori,2016)

There is no standard method for testing the tear strength of impression materials, since ISO 4823 (Dentistry-Elastomeric impression materials) does not address such a test method.(Kenneth ,2003) Unfortunately, specification no. 18 of ANSI/ADA did not determine a specific amount for tear strength of alginate. However, for alginates, tear strength vary from 0.4 to 0.7 kN/m, and this property is probably more important than the compressive strength.(Fayaz, Noori,2016)

In the current study the tear strength (N/mm) was tested following Webber and Ryge's method by (the trouser tear test) according to ISO 34-1. When compared the different thicknesses for each type of impression materials separately, the data showed that there were no significant difference of tear strength between three different thicknesses of each type of Alginate impression materials. But the comparison between alginate impression materials at different thicknesses by using the Tukey test. Which showed a significant difference between alginmax and cavex impression materials at a thicknesses (3 mm,and4 mm). While the difference at thicknesses (2 mm)was insignificant . Furthermore, the difference between cavex and conventional impression materials was significant for both thickness types (3 mm, and 4 mm) but the difference was insignificant at 2 mm . In contrast, the difference between alginmax and conventional type was insignificant at all different thicknesses.

This difference in result may attributed to difference in the compositions of each type of alginate may cause difference in physical and mechanical properties among materials hence different component.

The properties of alginate raw material depend largely on the degree of polymerization and the ratio of guluronan and mannuronan blocks in the polymeric molecules. The mannuronan regions are stretched and flat, whereas the guluronan regions contribute less flexibility. Also, mainly guluronan blocks bind with Ca^{2+}. Therefore, alginates rich in guluronan form strong, brittle gels, whereas those rich in mannuronan form weaker and more elastic gels.(Kenneth et al.,2013)

While when compared tear strength between three brand of impression materials at different thickness ,The data showed that there was a significant difference between all brand of impression material when testing every three types with same thicknesses. Cohen et al, who evaluated the tear strength of four alginate impression materials mixed according to manufacturers' instructions and found that there was a significant difference between them.(Cohen et al.,1998)

Clinical impressions for patients with proper contact areas showed that all the impressions were subjected to tearing. This may be due to the low tear strength of this hydrocolloid alginate impression, accompanied by the reduced thickness at these interproximal areas.(Abdelraouf et al., 2021) Therefore, it could be postulated that there is a critical clinical value for alginate tearing, which is highly dependent upon its thickness.

Abdelraouf et al. (2021) concluded that Although increasing the powder/water ratio of mixed alginate raised the resultant viscosity and tear strength by an in vitro test, no clear clinical difference in tearing was detected. The thickness of the alginate impression between adjacent teeth was a greater influencing factor, affecting tearing more than powder/water variation. This finding comply with result of current study which revealed that there was a significant difference of tear strength between the different thicknesses of Alginate impression materials.

The strength of alginate impression materials increases with thicker mix rather than thinner mixes utilized. The advantage of the use of increasingly thicker mixes is somewhat limited because the consistency becomes too thick, and the flow during seating of the impression is so low that an adequate impression cannot be obtained.(Zezo,2015) Sahin et al.(2017) concluded that All commercial extended-pour irreversible hydrocolloid impression materials tested in their study maintained their tear strengths after 120 hours of storage.(Sahin et al ,2017) Lawson et al (2008) suggests that thicker film thickness of elastomeric produce a lower tear strength (which is measured as force/area) as observation during comparing their study with previous one by Boghosian , Lautenschlager (2003).This observation contradicts our results, Where the tear strength of alginate material increase with increase thickness.

Two ingredients of alginate powder in relation to strength are alginic acid and diatomaceous earth.). The diatomaceous earth acts as a filler to increase the strength and stiffness of the alginate gel. It also produces a smooth texture and ensures the formation of a firm gel surface that is not tacky. Since this ingredient constitutes more than half of the ingredients, it can play an important role in alginate tear strength.(Kenneth et al.,2013)

A limitation of this study is that the exact cross-sectional area of the specimen during tearing could not be accurately determined. As the specimens were deformed and the cross-sectional area decreased.

Conclusion

6.Conclusion and recommendations

6.1.conclusion

Within the limitations of this study, the following conclusions were drawn:

1. Based on the result of this study, No differences was found between first poured casts and second poured casts of both alginate, addition silicone after immediate pouring except conventional type.

2. Clinically acceptable casts can be generated by double pour of new generation alginate materials.

3. Dimensional stability of alginate impressions was directly influenced by the type of alginate and the time of impressions which poured after different pouring time (storage time).

4. Alginmax impression could be poured after 5 days and Cavex color change impressions could be poured after 9 days of storage with no significant dimensional changes.

5. Alginmax impression materials shows significant dimensional changes after 9 days.

6. In general, when alginates are used, immediate pouring of the impressions is still the best method for precise reproduction of the teeth and adjacent tissues.

7. There is no difference in tear strength between the three different thicknesses of each type of alginate impression material.

8. There are difference in tear strength between alginmex and cavex and between cavex and the conventional type.

6.2.Recommendation for further researches

1.Study dimensional accuracy of these impression materials in clinical situation.

2.Study dimensional accuracy of repeated pouring impression material after storage time in different temperature.

3.Study dimensional accuracy of these impression materials mixed by distilled water compared with tap water.

4.Study effect of disinfectant agent on dimensional accuracy.

5.Test the dimensional accuracy of these material with another measuring device (digital device).

6. Measuring the dimensional accuracy directly on impression rather than the cast.

7.Test the tear strength after storage time.

Reference

Reference

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تقييم تأثير السُمك على مقاومة تمزق طبعات الألجينات ومقارنة دقة أبعادها مع السيلكون المتفاعل بالإضافة بعد الصب المتكرر

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الملخص

مادة طبعة الالجينات ، تستخدم على نطاق واسع في مواد الطبعات في طب الأسنان بسبب تكلفتها المنخفضة وسهولة التعامل معها. ومع ذلك ، هناك عيب في مواد الطبعات الغروانية وهي تغيير أبعادها ومقاومة منخفضة للتمزق. هدفت الدراسة الحالية إلى تقييم ثبات أبعاد قالب الأسنان المتحصل عليه من الألجينات بالإضافة إلى طبعة السيلكون لنموذج الأكريليك بعد الصب المتكرر وتقييم ثبات أبعاد طبعة الالجينات بعد فترات تخزين مختلفة (8/1 يوم ، 3 أيام ، 5 أيام ، 9 أيام). كما تم تقييم مقاومة التمزق لمادة طبعة الالجينات بسماكات مختلفة (2 مم ، 3 مم و 4 مم). وفيما يتعلق بدقة الأبعاد ، أظهر التحليل أن الصب المتكرر لمواد الطبعة لم يكن له تأثير ذو دلالة إحصائية على دقة الأبعاد حيث ان قيمة P < 0.05 باستثناء النوع التقليدي لمواد الألجينات ، وأظهر التحليل أيضًا عدم وجود فرق معنوي في دقة أبعاد القوالب المصبوبة بعد 5 أيام ، و 9 أيام لمواد طبعات (alginmax و cavex) على التوالي ، حيث كانت قيمة p أكبر من 0.05. بينما كان هناك فرق معنوي في دقة الأبعاد للقوالب المصبوبة بعد 9 أيام لمادة طبعة الجينمكس. في تحليل قوة التمزق ، لم يكن هناك فرق معنوي في مقاومة التمزق بين ثلاثة سماكات مختلفة لمواد طبعات الألجينات ، حيث كانت القيمة الاحتمالية (0.611،0.969، 0.516) لمواد طبعات(alginmax,cavex, and conventional,) على التوالي. الاستنتاج : يمكن إنشاء قوالب مقبولة سريريًا عن طريق الصب المتكرر لمواد الجينات من الجيل الجديد. تأثر ثبات أبعاد طبعات الألجينات بشكل مباشر بنوع الألجينات ووقت صبها بعد في فترات صب مختلف بدون تغييرات كبيرة في الأبعاد.حيث ان طبعة الجينمكس يمكن صبها بعد 5 ايام وطبعة الكافيكس يمكن صبها بعد 9 ايام من التخزين بدون تغيير في الابعاد. لا يوجد اختلاف في مقاومة التمزق بين ثلاث سمكات مختلفة لمواد طبعات الالجينات.

الملخص بالعربي

جامعة بنغازي

كلية طب وجراحة الفم والأسنان

قسم الاستعاضة الصناعية

تقييم تأثير ا لسُمك على مقاومة تمزق طبعات الألجينات ومقارنة دقة أبعادها مع السيلكون المتفاعل بالإضافة بعد الصب المتكرر

(دراسة مخبريه)

قدمت من قبل

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دكتوراه في طب مواد الاسنان

قدمت هذه الرسالة استكمالا لمتطلبات الحصول على درجة الماجستير

في طب مواد الاسنان

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