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Fundamentals and new concept of impression

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بسم الله الرحمن الرحيم

قَالُوا سُبْحَانَكَ لا عِلْمَ لَنَا إِلاّ مَا عَلّمْتَنَا

إِنّكَ أَنْتَ الْعَلِيمُ الْحَكِيم

صدق الله العظيم

سورة البقرة (آية ٣٢)

Certification of the Supervisor

I certify that this thesis entitled “**Fundamentals and new concept of impression”** was prepared by **Hadeel Bassim Waheed** under my supervision at the College of Dentistry/ University of Baghdad in partial fulfilment of the requirements for the for the B.D.S. Degree.

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1. Introduction

Successful indirect restorations depend on many factors, but chief among them is taking a good impression. An impression that does not precisely duplicate the prepared teeth will produce an inaccurate working model and result in poorly fitting restorations. Clinicians report that the impression-taking process is the most stressful restorative procedure, because of clinical technique and the impression material's inherent properties. Key factors involved in producing clinically acceptable impressions include managing soft tissue, appropriately selecting tray and impression material, and enabling impression material to flow predictably. Managing soft tissue is the most critical step in obtaining a perfect impression. Tray selection also plays a significant role with tray choice depending on the clinical situation and on the impression material and technique used.

Impression making is the first part of this process by creating a negative form of the teeth and tissues into which gypsum or other die materials can be processed to create the working analogues. This process is as much an art as it is a science. Dental practitioners should understand the properties of the materials and methods to manipulate these materials safely and effectively to capture the exact form of the oral tissues.

2. The history of dental impressions

Phillip Phaf first introduced the dental world to impressions in ***1775***, when he displayed the technique using softened wax . Clinicians soon discovered wax demonstrated too much distortion when removed. Many materials have been used since, some with better results than others. Plaster and zinc oxide-eugenol came next, and also quickly fell out of favor when it became clear they didn't have the ability to flex over and around undercuts without breaking .

The introduction of agar and alginate, both hydrocolloid materials, offered clinicians the better accuracy they craved, but with lower tear-resistance and decreased dimensional stability over time. Polysulfide rubber based impression materials were next in line, offering better accuracy and tear-resistance yet only minor improvements in dimensional stability. Polyethers came on the scene in the 1960s and condensation and addition-reaction silicones made their debut in the 1970s, eliminating the problems dental professionals experienced with poor stability and low tear-resistance. Of course they still had their limitations, continuing to prove no impression material was ideal for every clinical situation. Vinyl polysiloxane (VPS), the most popular impression material available today, offers dental professionals another option *(Hannon Pace Brinker,2018)*

The introduction of computer-aided design/computer aided manufacturing (CAD/CAM) technology in dentistry has resulted in more accurate manufacturing of prosthetic frameworks, and greater accuracy of dental impression, and the technology has improved since the 1980s.

3. Impression Material Properties

Impression materials continue to improve, but to know which material is best for various clinical situations, it's important to understand various impression material characteristics.

They include:

3. 1-Hydrophilicity, Wetting and Contact Angles

Impression materials are characterized by their degree of hydrophilicity. They may be hydrophilic, hydrophobic, or hydroactive . Surface wetting describes the relative affinity of a liquid for a solid and can be quantified by measuring the contact angle. A zero contact angle would indicate complete wetting of the surface whereas, a high angle would indicate less wetting. Moisture compatibility significantly impacts on the material's ability to accurately record surface detail in the intraoral environment.

- Hydrophilic materials have a high affinity for moisture (low contact angle), provide good surface wetting and allow for a high degree of surface detail.
- Hydrophobic impression materials have a low affinity for moisture (high contact angle); provide poor surface wetting and a lower degree of surface detail.
- Hydroactive impression materials are impression materials that are normally hydrophobic and are rendered hydrophillic through the addition of surfactants. These materials provide excellent surface wetting (low contact angle) as well as a high degree of surface detail.

However, it is necessary when discussing the wetting capability of impression materials to consider the materials' wetting ability to soft and hard tissues and also to gypsum slurry *(Terry et al,2017).*

3. 2-Viscosity (classification according to viscosity)

The term "viscosity" describes the flow characteristics of an unset impression material. The viscosity of the material increases with the proportion of filler presents. The impression material can exhibit a decrease in viscosity in response to high shear stress and this is called shear thinning. Thus, the viscosity of the impression material will vary in accordance with the shear stress.

The low viscosity material can be referred to as light body, syringe or wash material. These lower viscosity materials can flow easily into and record the fine details; however they are not usually used alone. They are used in conjunction with a second more viscous material to hydraulically propel and support the lower viscosity material *(Terry et al,2017).*

3. 3-Setting and Working Time

The setting time for an impression material is the total time from the start of the mix until the impression material has completely set and can be removed from the oral cavity without distortion.

The working time is measured from the start of the mix until the material can no longer be manipulated without introducing distortion or inaccuracy in the final impression.

The impression material must be completely mixed and seated in position before the end of the working time. Elastomeric impression materials have a working time of approximately 2 minutes and a setting time of between 2 and 6 minutes (i.e. fast and regular set). Generally, the working time corresponds to the setting time. Consequently, a fast-setting material will usually have a short working time and a slow-setting material will have a long working time.

The setting time of all elastomeric impression materials is affected by temperature. One method for extending the working time is to refrigerate the materials before mixing with increases of up to 90 seconds. Furthermore, lowering the temperature of the material below 65 C$^{\circ}$ will affect the flow of the pastes and result in altered base/catalyst ratios.

Other factors that can influence the setting and working time include humidity, base to catalyst ratio, and the manner in which the material was mixed *(*Terry *et al,2017).*

3. 4-Tear Resistance and Elastic Recovery

Impression materials should have adequate strength to allow removal without tearing. A material with higher tear energy provides resistance to tear for the impression. Elasticity allows the material to resist tearing and recover to its original pre-stressed configuration. The degree to which this occurs is a measure of the elastic recovery of the material. Permanent deformation can occur when the polymer is elongated beyond the point where elastic recovery is possible.

These two physical properties (tear resistance and elastic recovery) are important in preserving the accuracy of the impression during intraoral removal and after cast separation. Materials with sufficient tear resistance and elastic recovery will withstand multiple pours, producing several accurate casts. This is a major advantage in contemporary restorative dentistry *(*Terry *et al,2017)*

3. 5-Dimensional stability

An impression's ability to accurately replicate the intraoral structures is dependent upon its dimensional stability. The reasons for dimensional changes in elastomeric impression materials include the following: contraction due to reduction in spatial volume following polymerization, reduction in set volume from liberation of by-product or accelerator components, water absorption from wet or varying humidity environments and changes in temperature. Materials with sufficient dimensional stability can remain unchanged for a reasonably prolonged period of time (7 days), and resist temperature extremes during shipping while retaining the ability to produce multiple accurate casts *(*Terry *et al,2017)*

3. 6-Surface Detail

Surface detail is the ability of an impression material to accurately reproduce the surface of an object and is related to the viscosity of the impression material; low viscosity produces better detail. High-viscosity putty materials have poorer detail reproduction. Smooth, rounded preparations reproduce better with all impression materials and die stones. Retraction cord medicaments (aluminum chloride, ferric sulfate, and ferric subsulfate/ferric sulfate, etc.) adversely affect the surface detail reproduction of PVS impressions. The sulcus should be rinsed thoroughly to remove all traces of the hemostatic agent applied to the retraction cord prior to making a PVS impression *(*Terry *et al,2017).*

4. Classification of Impression Materials

Various materials are available for making a precision negative mold of soft and hard tissue. Each material has advantages and disadvantages, and none is entirely free of shortcomings, impression materials classified into:

1- Non-elastic impression materials

a. Impression plaster

B. Impression compound

C. Zinc oxide eugenol

2-The elastic impression materials

a. The hydrocolloids :agar, alginate

b. ***the synthetic elastomers: polysulfide, silicone, polyether***

However, they all share one important characteristic: When handled correctly, they can produce casts of sufficient accuracy and surface detail for the fabrication of clinically acceptable fixed prostheses.

4.1 Elastomeric impression materials

4.1.1 Hydrocolloid impression materials

- **Alginate hydrocolloids**

Alginate impression materials dimensionally unstable due to absorbing (by imbibition) as well as giving off (by syneresis) water to the atmosphere and this will lead to impression distortion. Therefore, alginate impression materials must be poured immediately (Imbery *et al.*, 2010). Alginate impression materials change from the sol phase to the gel phase and the material cannot be converted back to a sol, so these impression materials called (irreversible hydrocolloids) (Powers and Sakaguchi, 2012).

- **Agar hydrocolloids**

Agar was introduced into dentistry for making crowns impression by Sears in 1937. However; it is not commonly used today because of the need for expensive conditioning baths and water cooled trays (Wassell *et al*., 2002).

4. 1.2 Non-Aqueous Elastomeric Impression Materials

Elastomers are a group of synthetic elastic impression materials which consist of polymers bind together to form a network of chains that give material a rubber consistency. Because of their good properties like excellent reproducibility, good tear resistance, and sufficient dimensional stability, they are used as a final impression in fixed prosthodontics (Markovic *et al*., 2012).

I. Polysulfide Polymer

Polysulfide impression materials are supplied as a base which consists of polysulfide polymers, titanium dioxide and calcium sulfate, while the catalyst consist of lead dioxide, dibutyl phthalate and sulfur (Powers and Sakaguchi, 2012). Polysulfides have the longest history use, and introduced in dentistry in 1950. They are available in different type of viscosities mainly, low viscosity, medium viscosity and high viscosity (Wassell et al., 2002). Polysulfides have high tear resistance and good detail reproduction. However; these materials are now relatively unpopular materials due to long setting time, dimensional instability because of the release of water by-product, messy to handle, have an objectionable odor and ability to staining clothing permanently (Wassell et al., 2002; Rosenstiel et al., 2002).

II. Condensation Silicone

Condensation silicones were introduced to dentistry in the early 1960.These are supplied as a base which contains a polydimethylsiloxane and an accelerator that consists of stannous octoate suspension with alkyl silicate (Powers and Sakaguchi, 2012). Some of the disadvantages of polysulfide have been overcome by condensation silicone, which is essentially:

- Odorless and can be pigmented to virtually any shade. Unfortunately, its dimensional stability is less than that of polysulfide, but it is greater than that of reversible hydrocolloid.
- Relatively short setting time in the mouth (about 6 to 8 minutes). As a result, patients tend to prefer condensation silicone over polysulfide.
- Condensation silicone is also less affected by high temperatures and humidity in the operating room.

The main disadvantage of silicone is its poor wetting characteristics, which stems from its being extremely hydrophobic (for this reason, it is used in commercial sprays that protect automobile electrical systems from moisture Silicone impression material is available in various degrees of viscosity. (Rosenstiel *et al,2016*).

III. **Polyether**

The first type of polyether introduced in dentistry in 1965. Initially available in a single regular viscosity and by the use of a diluent slight modification of the viscosity is achieved (Wassell *et al.*, 2002). The base paste consists of polyether copolymer with reactive terminal groups and silica filler, while the catalyst paste contains sulfonate catalyst, coloring agents, and silica filler (Powers and Sakaguchi, 2012).

Polyether impression material has high accuracy in the reproduction of details as a result of its initial hydrophilicity and dimensional stability as a material has no reaction by-product. However; the set material may swell and distort during storage in conditions of high humidity (Wassell *et al.*, 2002).

Polyethers have adequate tear resistance and very good elastic properties. However; they are relatively rigid than other elastomers when set, therefore significant force may be applied during the impression removal from both the mouth and stone cast. This may prevent their use in cases with sever undercuts (Giordano, 2000; Wassell *et al.*, 2002).

IV. **Addition Silicone**

In 1970 addition silicone was introduced to dental field. The base material contains a polymethyl hydrogen siloxane copolymer, which is a low molecular mass polymer that is terminated with silane groups. The accelerator contains a low-molecular mass vinyl terminated polydimethyl siloxane and platinum salt catalyst, so they are called polyvinyl siloxane (Powers and Sakaguchi, 2012).

PVS are available with various viscosities, depending on the concentration of fillers in the base, from very low viscosity (for use with a syringe or wash material) to medium, high, and very high (putty) viscosity. Viscosity is also affected by the shear force placed on the material. This is termed shear thinning.

Addition silicones are the most stable impression materials because no by-product is produced during polymerization resulting in a very stable impression which remains unchanged over a substantial period of time, allowing the impression to be poured some degree some days or even weeks after taking the impression.

PVS are reported to have the best elastic recovery and less permanent deformation than the other elastomers (Anusavice, 2003).

Like condensation silicone, addition silicones are hydrophobic. Some formulations contain surfactants, which give them hydrophilic properties, imparting wettability similar to that of the polyethers. One disadvantage of some of these materials is that setting can be inhibited by selected latex gloves or by interim resin materials.

Manufacturer recommendations should be followed when a cast is being poured, and pouring should be delayed with some of the earlier products; otherwise, a generalized porosity of the cast surface will be caused by gas from the impression material. Newer products contain "scavengers", chemicals that prevent the escape of gas at the polymer-cast interface *(*Rosenstiel *et al,2016).*

V. Vinyl Polyether Silicone

Vinyl polyether silicone is a formulation that combines properties of the addition silicones and the polyethers. It was commercially introduced in 2009. It is a new chemical compound developed by combining polyether polymer and vinyl groups of VPS. With the polyether groups, a hydrophilic material is provided without the use of a surfactant. With the siloxane groups on the polymer chain, a material that is dimensionally stable and recovers from deformation is combined with polyether properties (Rosenstiel *et al, 2016*).

. The material has a platinum catalyst, and the setting reaction is contaminated when powdered gloves are used to mix the material.

Little independent evaluation is available on the hybrids, but manufacturers' data suggests that these products are hydrophilic during setting and after polymerization. They are supplied as putty, heavy, medium, and wash materials. An additional benefit is that they do not have the bitter taste of polyether materials and have a pleasant spearmint flavor. These hybrid materials may represent the blend of hydrophilicity and hydrophobicity necessary to improve impression making by wetting the tooth well and pouring easily for cast fabrication.

5. Tissue Management

Healthy periodontal tissues are essential for the success of the impression-taking procedure. Inflammations of gingival tissues prior to impression taking can complicate the procedure. Bleeding and moisture from crevicular fluid can displace Impression material and may result in voids and rounded indistinct finish lines that could cause an inaccurate cast and inadequately fitting final restorations. Furthermore, if a subgingival margin is placed in the presence of inflammation there is a potential risk of gingival recession and exposure of the restorative finish line. Therefore, a fundamental requirement for achieving excellence in impression taking is management of the soft tissues (Herbert T. Shillingburg *et al*,2012) .

5.1 Gingival retraction

Gingival retraction is the process of temporary displacement of the gingival tissue margin away from the prepared teeth with minimal damage to the attachment apparatus of these teeth (Nitai *et al*., 2013).

The aims of gingival retraction are (Donovan and Chee, 2004):

1. To retract the gingiva vertically to get access for the impression material to the epigingival or subgingival preparation margins and a portion of the apical unprepared tooth substance.
2. To retract the gingiva horizontally to obtain enough space between the tooth and the gingiva to allow the impression material to flow easily below the preparation margin and to obtain enough material thickness. Increased material thickness increases the strength of the impression and decreases the risk of tearing when it is removed from the mouth.
3. To keep the surfaces of the prepared tooth dry while taking the impression.

A gingival retraction agent should be: (1) Effectiveness in gingival retraction and hemostasis. (2) Rarity of untoward systemic effects. (3) Absence of irreversible trauma to the gingival tissue (Shujaulla *et al*., 2012).

5.2 The forces involved with retraction of periodontal tissues

Distortion of gingival tissue during displacement and impression procedures includes four forces: retraction, relapse, displacement and collapse (Shah *et al*., 2012).

5.3 Techniques of Gingival Retraction

Gingival displacement can be accomplished using several different techniques. No clinical study has demonstrated the superiority of one technique over another, so the choice of which procedure to use depends on the presenting clinical situation and operator preference.

1. Mechanical retraction.
2. Chemo-mechanical retraction.
3. Displacement pastes.
4. Surgical retraction.

1. MECHANICAL

Among the first techniques developed and available to clinicians for displacement of gingival tissues, especially for crown and bridge impressions, were mechanical displacement. Mechanical displacement refers to physically moving the gingival tissues aside from the tooth/tooth preparation margins to allow for visualization and access for treatment. In many cases, the materials used for gingival retraction can be used by themselves or in combination with other materials and techniques.

- **Plain retraction cord**

A non-medicated cord utilized to obtain some displacement of the gingival tissue when placing it and leaving it in the area for an adequate length of time. The plain cord is a process of pushing the gingival tissue, which mechanically stretches the circumferential periodontal fibers (Rosenstiel *et al.*, 2002).

From a clinical point of view, the gingival sulcus collapsed soon after the removal of the cord. Hemostasis achieved was limited and the placement of the cord in the gingival sulcus was time consuming (Albaker, 2010). Moreover, a histologic study confirms trauma to the epithelium of the gingival sulcus and connective tissue attachment during placement of retraction cords as a result of contamination of the gingival sulcus wounds with residual filaments/fibers of the cord (Shah *et al.*, 2012).

Application of the inappropriate amount of force during placing of the retraction cords can also cause crevicular bleeding, gingival tissue inflammation and shrinkage of gingival margin tissues (de Gennaro *et al.*, 1982).

Plain cords (non-medicated) are not a good choice for gingival tissue displacement, as the sulcular hemorrhage cannot be controlled only by the pressure applied by the cord on the gingival tissues (Ruel *et al.*, 1980). More than 50% of the situations are associated with bleeding on removal of the plain retraction cord, although wetting the cord before removal may play a crucial role in controlling bleeding from the gingival sulcus.

Guidelines about the amount of time the cords should stay in the gingival sulcus in order to gain sufficient tissue retraction have ranged from 3-15 minutes.

Classification of Retraction Cords

1. Depending on the configuration: Knitted, braided, twisted.
2. Depending on surface finish: Waxed and unwaxed.
3. Depending on the chemical treatment: Impregnated and plain.
4. Depending on number strands: Single and double-string.
5. Depending on the thickness (color coded): Black-000, yellow-00 purple-0, blue-1, green-2, red-3.

i. Single-Cord Technique

This technique involves a single retraction cord placed in the sulcus and removed just before taking the impression. The single-cord technique is effective if the margins are supragingival or equigingival. It may not be as effective if the margins are subgingival, because the gingival tissue rapidly collapses back over the margins when the cord is removed. This prevents the flow of impression materials apical to the margin.

ii. Double-Cord Technique

This technique uses two layers of cord of differing thicknesses. It can prevent tissue collapse and bleeding, helping to achieve perfect impressions. However, careful technique is required to avoid tissue damage. In the case of a shallow sulcus or friable tissue, use only one cord.

- **Merocel Retraction Strips**

Synthetic retraction materials are chemically extracted from a biocompatible polymer (hydroxylate poly vinyl acetate) that creates net-like strips. The material, which can be easily shaped and adapted into the sulcus without local anesthesia, is slightly effective for the absorption of intraoral fluids, such as saliva, blood, and crevicular fluids. Once inserted around the tooth, the sponge-like strips expand with the absorption of fluids and exerts pressure on the gingival tissue to cause displacement.

- **Matrix impression system**

In **1998, Livaditis** introduced a system that requires three impression procedures, utilizing three viscosities of impression materials termed “Matrix Impression System”. This technique appears to facilitate the fabrication of complex impressions. It seems to overcome some important deficiencies in the registration of subgingival margins, by helping in gingival retraction, hemostasis and sulcular cleansing, delivering the impression material subgingivally and strengthening the sulcular flange of the impression.

At first, a matrix of an occlusal registration is made over tooth preparations before gingival displacement is done using elastomeric material (semi-rigid). The matrix is cut to prescribed dimensions and after the cord is removed, a definitive impression is made in the matrix of the preparations utilizing a high viscosity elastomeric impression material. After the matrix impression is seated in place, a stock tray is placed over the matrix and the remaining teeth, which filled with a medium viscosity elastomeric impression material to make an impression of the entire arch (Livaditis, 1998).

The matrix impression system maintains retraction by surrounding a highly viscous material in the gingival sulcus when the matrix is fully seated. This system has only one noticeable drawback which increases chairside time (Shah *et al.*,2012).

2. CHEMO-MECHANICAL TECHNIQUE

The chemical aspect of the method involves treatment the string with one or more of a number of chemicals that will cause a temporary shrinkage of the tissues and should also control the hemorrhage and fluid seepage that often occur in subgingival margin preparation while mechanically, the cord is displaced the gingival tissue from the tooth margin physically (Albaker, 2010).

A variety of chemicals, in the form of solution or gel, have been used with the gingival retraction cords because of the properties of these chemicals to act as a hemostatic agent or astringent. In most cases, these chemicals are both astringent (causing contraction-retraction of the gingival sulcus) and hemostasis (constricting blood flow through coagulation). When these reagents are combined with the retraction cord, they cause a transient ischemia, shrinking the gingival tissue and blood vessel coagulation. Common astringent-hemostatic agents include:

aluminum chloride, racemic epinephrine and ferric sulfate (Strassler and Boksman, 2011).

3. Displacement pastes (Cordless Retraction Pastes)

A complete paradigm shift has been made with the introduction of a very novel idea to obtain displacement and hemostasis at one time (Phatale *et al.*, 2010)**.** These materials are available in paste- and gel-like form and supplied with a specialized dispenser to retract the gingival tissue by means of its high viscosity when injected into the gingival sulcus (Yang *et al.*, 2005)**.** They are less traumatic than the conventional retraction cord. They have been found to be better than cords when assessed histologically (Phatale *et al.*, 2010). They are preferred for gingival retraction in implant prosthesis. They are also used to gain digital impressions for the CAD/CAM prosthesis (Lylajam and Prasanth, 2012).

- **Expasyl®**

Expasyl® (Kerr) was the first paste system introduced as an alternative to retraction cord and special hemostatic agents and was developed in France by Pierre Rolland Aceton Labs. It contains Kaolin matrix and 15% aluminum chloride (Einarsdóttir, 2012). It has both mechanical and chemical actions. Mechanically, it creates and maintains space in the sulcus mainly due to its kaolin component. Chemically, it has a hemostatic effect due to aluminum chloride. It remained in position for 2 minutes, then rinsed properly to completely remove from the sulcus as residue of the ingredient, aluminum chloride, can affect the setting of polyether impression material and gingival sulcus opening obtained is 0.5 mm (Kamath *et al.*, 2011).

- **Traxodent**

Traxodent (Premier) contains hemodent (Premier) and 15% aluminum chloride. It does not require a special delivery system as shown in. Traxodent paste flows easily and produces gentle pressure on the gingival sulcus. Traxodent can be combined with cords. This system contains a Premier Retraction Cap, which is an anatomically stiff cotton roll-like adjunct, which exerts physical action on the gingival tissue and guides the material into the gingival sulcus and also absorbs fluid, which aiding in obtaining hemostasis (Mechanic, 2013).

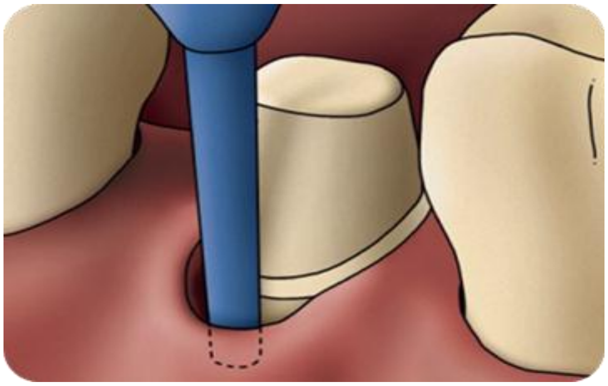
- **Racegel**

Racegel (Septodont) is a flavored gel-like product containing 25% aluminum chloride, has thermosetting properties, means that being liquid at room temperature and converting into a gel when applied in contact with the gingival tissues (Mechanic, 2013). This property is reversible, ensuring easy rinsing with water. This gel helps to prepare the sulcus prior to impression taking, control of bleeding and gingival oozing, particularly in restorative dentistry and can be used with or without gingival retraction cord. A sufficient amount of gel is placed into the gingival sulcus, slowly following the contour of the prepared tooth, remained in place for about 2 minutes, rinsed and gently dried and then the impression is taken (Septodont, 2013).

- **Astringent Retraction Paste**

Astringent Retraction Paste (3M™ ESPE™) is a paste-like product, consisting of kaolin material, 15% aluminum chloride, water, mica group minerals and polydimethylsiloxane (Bennani *et al.*, 2014). The kaolin is an aluminum-silicatehydrate, absorbs GCF and expands, similar to Expasyl® (Einarsdóttir, 2012), while aluminum chloride as an astringent, which has a hemostatic effect results from the compression on the gum, this hemostatic effect quickly closes any blood vessels which might be unintentionally opened (3M ESPE, 2012).

The material is dispensed in hygienic unit dose capsules. Its placement tip is extra-fine and has a soft edge tip, which facilitates access to the gingival sulcus, especially in interproximal regions. Like all the other systems, Astringent Retraction Paste (3M™ ESPE™) can be aided into the gingival sulcus with a cotton pellet or a retraction cap, remained in place for 2 minutes (Mechanic, 2013).(figure1)



(fig1)

- **Magic Foam Cord**

Magic foam cord is an easy, efficient but expensive way for taking precise impression. Magic foam is actually a polymeric material, which has to be introduced into the gingival sulcus and allowed to set under pressure. During setting, the material slightly expands, pushing the gingiva, producing excellent lateral displacement and good vertical displacement. Along with the material, circular foams that are contoured to the shape of gingival sulcus are supplied in three sizes to accommodate different teeth. The patient is asked to bite and keep the pressure on for 3 min. Retraction paste (magic foam cord, expasyl) showed better results on gingival health as compared to impregnated retraction cord when assessed histologically in respect to periodontium (Phatale *et al*. 2010).

- **Gingitrac (Centrix)**

It is an effective gingival retraction system based on vinyl polysiloxane material with aluminium sulfate astringent. It truly harnesses the power of pressure, astringency and time unlike traumatic cord techniques or messy paste alternatives. GingiTracuses an auto mixing gun to deliver the perfect combination of mild built-in astringency to control hemostasis. Unlike with retraction cord, the coagulum will not stick to the silicone GingiTrac, so there is no bleeding when it is removed. A GingiCap is used for single preparation retraction which works in less than 5 minutes, without hands in mouth and blanches the gingiva till the vestibule. It works gently with no tissue trauma to provide more accurate impressions. The convenient single-dose tips are much easier to handle than a bulky automix gun and are cost effective(figure2)

(fig2)

4. SURGICAL

I. Rotary Curettage (Gingitage) Troughing Technique

The purpose of which is to produce limited removal of epithelial tissue in the sulcus while a chamfer finish line is being created in tooth structure. Concept of using rotary curettage was described by Amsterdam in 1954 and further developed by Hansing and Ingraham.

Gingitage involves simultaneous subgingival tooth preparation and intentional rotary diamond instrument curettage of the inner lining of the gingival sulcus. The definitive tissue removal allows room for the placement of retraction cord and insertion of impression materials. There was no significant difference between the cord displacement technique and the gingitage technique (Tupac and Neacy 1981). Recession of clinical magnitude was induced only by rotary gingival curettage when compared with retraction cord and electrosurgery. Apical migration of junctional epithelium was not seen in all the three techniques (Azzi *et al.* 1983). Rotary curettage was efficient and predictable technique for retraction, but it created recession on thin tissues than on thick (maxillary anterior fixed partial denture) palatal tissues (Kamansky *et al.* 1984).

II. Electrosurgery or Surgical Diathermy

Electrosurgery unit is a high frequency oscillator or radiotransmitter that uses either vacuum tube or a transistor to deliver a high-frequency electrical current at least 1.0MHz. Electrosurgery is used in restorative dentistry to elongate the clinical crown, create a subgingival sulcus, and reduce excessive height of hypertrophic tissue from edentulous areas.

Combination of electrosurgery of marginal gingival tissues and retraction by placing the cord in the gingival sulcus allows making of accurate impressions of multiple prepared teeth with advantages of ample working time, ease of operation and impression free from capillary seepage.

III. Soft Tissue Laser

Soft tissue lasers have been introduced into dentistry and can provide an excellent adjunct for tissue management before impression making. They are also useful for tissue contouring procedures. They enable predictable removal of tissue by creating a trough around the prepared tooth. The diode laser, which operates at a low wavelength near infrared, has been claimed to result in minimal or no discomfort for the patient and no tissue recession, and it has been found to be more effective than conventional displacement at establishing hemostasis(Rosenstiel *et al*, 2016).

IV. Radiosurgery

Radiosurgery is a technique that provides cutting and/or coagulation from radio waves. An advantage over electrosurgery is that minimal lateral heat is generated. Different waveforms are used for tissue removal or coagulation(Rosenstiel *et al*, 2016)

6. Impression Techniques

Three common techniques are used for making impression for fixed prosthodontics: a dual-viscosity technique, a single-viscosity technique and a Putty-wash technique (Powers and Sakaguchi, 2012).

6.1 Double mix technique

This technique usually used with materials have two viscosities (heavy & light body).we mix the heavy body and light body at the same time. the light body is loaded in the syringe, while the heavy body loaded in special tray, then remove the displacement cord and gently dry the preparation with compressed air. The tip should be inserted into the most distal embrasure first this will prevent the material from flowing down over the preparation and trapping air bubbles. then the special tray loaded with the heavy body is inserted inside the patient mouth & seated over the dental arch ,the pressure created by the heavy body after seating of the tray causes a direct flow of the light body into the detail of the preparation including the finishing line.

6.2 Single-viscosity (monophase) technique

Impressions are made using a medium viscosity material. Polyether and addition silicone impression materials are used for this technique because both have a capacity for shear thinning, thus a medium viscosity impression material exhibited a lowered viscosity when subjected to high shear stresses occurs during syringing and mixing. The viscosity of the same material loaded in the tray is unaffected (Mandikos, 1998; Powers and Sakaguchi, 2012).

6.3 Putty-wash technique

The putty-wash technique is a two-step impression procedure whereby a preliminary impression using high- or putty-viscosity material is taken before tooth preparation. A low viscosity material is syringed in the area after tooth preparation and the preliminary impression is reinserted. This technique was used for addition silicone to reduce polymerization shrinkage and the need of custom impression trays (Powers and Sakaguchi, 2012).

Another alternative technique is using spacer which known as foil technique. Here, the resulting space approximately (2mm), thick plastic foil was placed over the tray that filled with putty impression material and then taking the first impression. The spacer provides a uniform space for the light body with which final impression is recorded (Wöstmann *et al.*, 2008).

6.4 Closed-mouth Impression Technique

The closed-mouth impression technique, also called the dual-arch or triple-tray technique, is popular for making impressions for single units and less expensive restorations made to conform to the existing occlusion. The impression is made in maximum inter-cuspation with a high-viscosity polyvinyl siloxane or polyether impression material supported by a thin mesh in a frame. Similar success rates have been reported with these impression material types. The impression includes the prepared tooth, the adjacent teeth, and the opposing teeth and records their maximum intercuspation relationship (hence the name “triple tray”). Because the impression is made at the occlusal vertical dimension, the technique facilitates making an accurate impression and occlusal record. However, the laboratory stages must be performed very carefully and, as no eccentric relationships are recorded, after the restoration has been fabricated, these need to be evaluated and adjusted at the delivery appointment (Rosenstiel *et al*,2016).

7. Impression Evaluation

The impression must be inspected for accuracy when it is removed. If bubbles or voids appear in the margin, the impression must be discarded. An intact, uninterrupted cuff of impression material should be present beyond the margin circumferentially. Streaks of base or catalyst material indicate improper mixing and may render an impression useless. If the impression passes all these tests, it can then be disinfected and poured to obtain a die and definitive cast (Rosenstiel *et al*,2016).

8. Disinfection

When they are removed from the patient’s mouth, it must be assumed that all impression materials have been in contact with body fluids. The materials should be disinfected according to the recommended procedures for the material being used. After being removed from the patient’s mouth, the impression is immediately rinsed with tap water and dried with an air syringe. Suitable chemicals should be used for disinfection, such as glutaraldehyde solutions or iodophor sprays. Some are perfectly acceptable for one material but unsuitable for others. Because of its tendency to distort and absorb moisture, polyether or “hydrophilic” addition silicone impression materials should be sprayed and stored in a plastic bag rather than submerged and soaked in a glutaraldehyde solution. Disinfection is an essential step for preventing cross infection and exposure of laboratory personnel. If it is performed properly, disinfection does not affect the accuracy or surface reproduction of the elastomer (Rosenstiel *et al*,2016) .

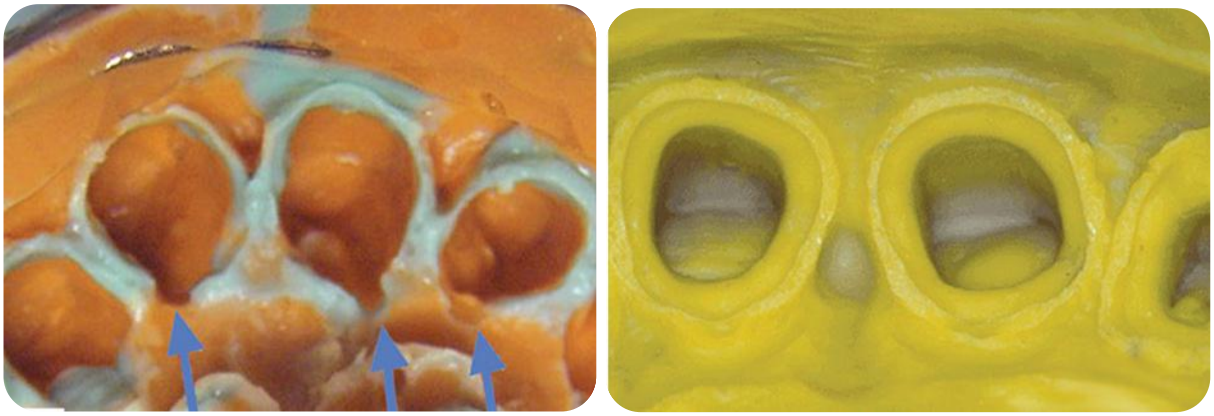
9. Pouring of dental impressions

One of the most important factors that affects on the accuracy of impression material is the time elapsed between securing the dental impression and when the impression is poured *(Donovan and Chee, 2004)*. The selection of gypsum products depends on the particular impression material used and the purpose that is made for. In addition cast and die materials must duplicate the impression details accurately and must have dimensional stability under normal storage and usage conditions *(/ 2006)*. Therefore, deciding the exact time of pouring impression is a mandatory step during the fabrication of dental prosthesis. However; a delay in pouring may be necessary to allow the material to recover elastically and to allow the release of by-products which may influence the accuracy of stone dies *(Eduardo et al., 2007)*. Water-based impression materials (hydrocolloids) should be poured within 10 min of removal from the mouth. Polysulfides and condensation silicones produce water and ethyl alcohol as a by-product respectively.

10. Errors in impression making

- **Inadequate Margin Detail**

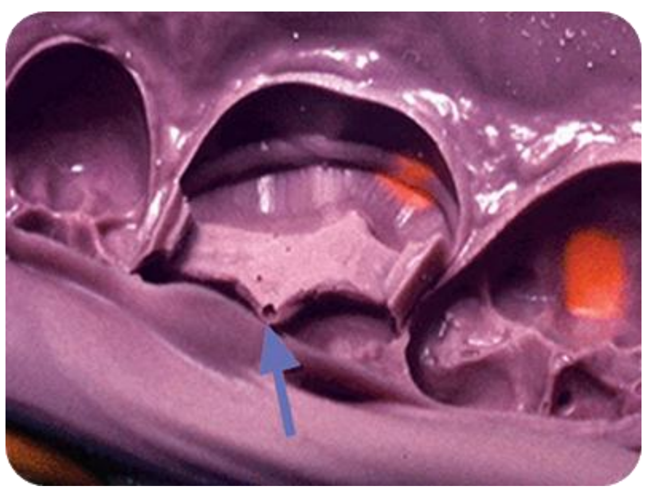
The primary complaint laboratory technicians have with the impressions they receive daily is inadequate marginal detail. Marginal detail is the most critical aspect of the impression. Failure to capture the true details of the margin of the preparation will result in open margins and inadequate prosthetic fit. Voids at the margins are the result of either insufficient retraction or fluid accumulation that prevented the impression material from flowing around the margin. This can be avoided by using improved retraction methods such as syringeable hemostatics (e.g., Expasyl™), or Comprecaps (Coltène) (Gregori M. Kurtzman, 2018). (fig3,4)



(figure3,4)

- **Internal Bubbles**

Internal bubbles occur as a result of either fluid accumulation (when larger and less sharp in definition) or air entrapment (when small and well defined). Bubbles on the margins of the preparations can negatively affect the fit of the prosthetics. If the bubbles occur on the internal line angles of inlay and onlay preparations due to fluid accumulation, a substandard fit will be developed. If they occur due to air entrapment, fit will not be compromised(figure5)



(fig5)

These errors may be avoided by thorough flushing and drying of the preparation prior to impression taking. Placing a curved intraoral impression tip into the deepest part of the preparation floor and extruding a light body polyvinylsiloxane (PVS) material will force air out of the preparation, decreasing entrapment(**Gregori & Kurtzman, 2018**).

- **Marginal Tears**

Marginal tears usually occur when a syringeable material with insufficient tear strength is used. Tear strength will vary between manufacturer and viscosities. These deformities can result when using a syringeable PVS in a thin deep sulcus. Removal of the impression prior to complete setting of the syringeable material may also cause marginal tearing(figure6)

(fig6)

To avoid that, additional tissue retraction may be indicated to facilitate use of a thicker syringeable material. Switching to a more viscous syringeable material may further prevent development of another tear. Syringeable hemostatic materials can be used to limit the amount of fluid evident in the treatment area, and the patient can be instructed to occlude into a cotton device for several minutes, thereby physically pushing the tissue away from the tooth and forcing the chemostatic deeper into the tissues (**Gregori M. Kurtzman,2018**).

- **Drags and Pulls**

A common complication encountered when using more viscous impression materials (e.g., putty or heavy body materials) is drags and pulls. A drag results when long, rounded depressions that resemble the cuspal edges of the teeth are left in the impression material upon insertion of the tray (Gregori M. Kurtzman,2018). Whereas, a pull (also referred to as a fold) results when the material creates a fold in the material, usually at the gingival aspect. These deformities can both result from:

- Impression material beyond its working time (no longer in its most fluid state).
- Failure of the impression material to adapt to the teeth.
- Improper insertion of the tray.

Drags and pulls can be avoided by using a less viscous material either syringed around the teeth or placed over the more viscous material in the tray prior to insertion(figure7)

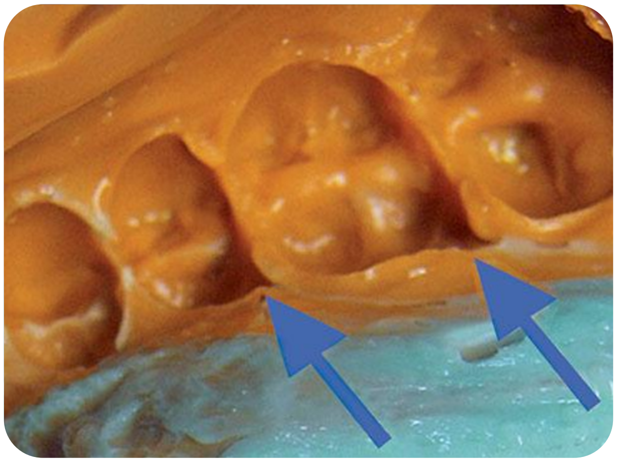


fig7)

Correction of a pull in the impression can be accomplished by removal of the interproximal impression material so the impression can be reinserted without interference. A syringeable impression material (light or extralight) should be placed over the entire impression, and the depressions should be filled. The impression can then be reinserted intraorally. Drags, on the other hand, often are not correctable by adding additional material, as they may have caused distortion of the tray. Avoiding contact between the tray and the teeth will help avoid these deformations(Gregori M. Kurtzman,2018).

- **Separation from the Tray**

Separation of the impression material from the tray may not be obvious until the restoration is returned and tried in(figure8)

(fig8)

This deformity may be overlooked when using trays with slots and holes to lock the impression material. Tray adhesive should be used with all impressions to help eliminate impression separation from the tray.[8] Roughen, create holes for mechanical retention, and clean the inner surface of tray with alcohol before applying adhesive(Gregori M. Kurtzman,2018).

- **Inadequate Impression Material Mixing**

Once the impression material is combined, it should contain a uniform color with no streaking. Streaking is more common with hand mixed putty materials than with cartridge materials when completed(Gregori M. Kurtzman,2018).

- **Cast Discrepancies**

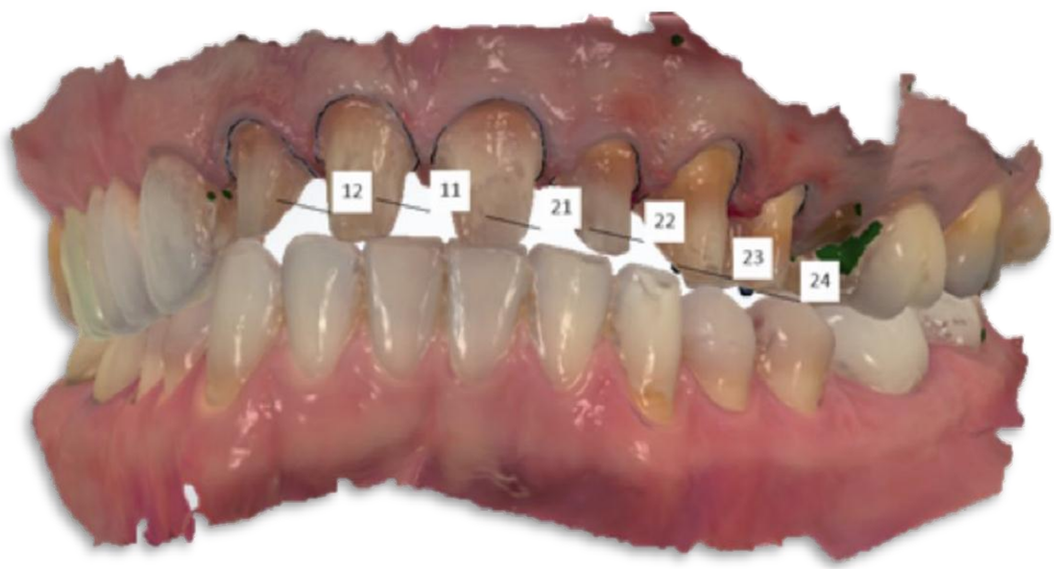
Large bubbles on the cast will correspond to a defect in the impression material. These bubbles are invariably caused by an insufficient amount of impression material or air trapped between the impression material and the arch at tray insertion. These defects can be avoided by syringing material around the teeth and into the vestibule prior to tray insertion(figure9)

(fig9)

A cast that is covered with multiple tiny voids while the impression does not have corresponding defects can be the result of hydrogen gas release from the impression. Hydrogen is a by-product of PVS polymerization. Should the cast present with this defect, if the impression is still intact it can be re-poured. This defect can be avoided by following the manufacturer's recommendation with regard to the duration that should be observed prior to pouring the cast(Gregori M. Kurtzman,2018).

11. DIGITAL IMPRESSION

Digital impressions represent innovative methods that enable dentists to construct a virtual, computer-generated copy of the hard and soft tissues of the oral cavity, with the use of lasers and other optical scanning machines. The digital method captures impression data with great accuracy, in minutes, without the need for traditional impression resources that some patients find inopportune and messy. Numerous patients consider digital impressions to be an easier and more comfortable method, in comparison with classical impression techniques. The impression information is then moved to a computerized workstation that creates restorations, often without the need for stone models.(figure10)



(fig10)

11.2 Intraoral scanners (IOS)

IOS are devices for capturing direct optical impressions in dentistry. Similar to other three-dimensional (3D) scanners, they project a light source (laser, or more recently, structured light) onto the object to be scanned, in this case the dental arches, including prepared teeth and implant scan bodies (i.e. cylinders screwed on the implants, used for transferring the 3D implant position). The images of the dentogingival tissues (as well as the implant scanbodies) captured by imaging sensors are processed by the scanning software, which generates point clouds. These point clouds are then triangulated by the same software, creating a 3D surface model (mesh). The 3D surface models of the dentogingival tissues are the result of the optical impression and are the 'virtual' alternative to traditional plaster models(figure11)

(fig11)

11.3 Types of Intraoral Scanners

Digital impressions obtained by intraoral scanning devices were originally a part of CAD/CAM systems. These in-office systems (eg, CEREC®, Sirona Dental Systems, E4D® Dentist, E4D Technologies,) produce a digital impression of prepared teeth. Computer-assisted design of the final prosthesis is completed, and the file is sent to an in-office milling machine, where the final prosthesis is milled from a ceramic or composite block.

More recently, intraoral scanners were introduced as stand-alone devices that capture a digital impression and send the file to a dental laboratory for prosthesis fabrication. Intraoral scanners that are commercially available include the iTero™ Digital Impression System, True Definition Scanner, and IOS FastScan™ In addition, both Sirona (CEREC AC Bluecam and CEREC Omnicam) and E4D (NEVO™) have developed units and software for sending digital impressions from in-office scanners to dental laboratories.

Intraoral scanning systems use fundamentally different imaging technology to capture their 3D images:

CEREC bases its imaging on triangulation, a technique in which a light source is reflected off an object and depth-dependent shifts in the light are detected by a sensor. Light triangulation limits accuracy when scanning curved surfaces—especially those that do not reflect light evenly, such as teeth with amalgam restorations. To correct this problem, surfaces to be imaged are coated with an opaque, reflective coating. An uneven or overly thick coating may compromise the accuracy of these systems(Baheti,2015).

Their original standalone intraoral scanner, ***CEREC AC*** (Sirona Dental Systems) with Bluecam technology, projects visible blue light with a shorter wavelength than previous models, improving scanner accuracy and reducing the amount of powder required for light reflection(figure12)

(fig12)

Sirona recently released the ***Omnicam***, which uses a powder-free, full-color video capturing system. The scanner collects white light video, which can be used to create a photorealistic image of the tooth. The files from these systems are then sent to an external laboratory using Sirona Connect softwar e (Baheti,2015).

The original system from E4D, ***the E4D Dentist***, uses oscillating laser light to capture a digital image. Lasers differ from traditional light sources in that they are produced from a single wavelength of light, making them more accurate but unable to capture color information. ***The new NEVO system*** (which has replaced the E4D Dentist) is a powder-free sensor that operates by use of a blue laser. The scanner can be plugged into a laptop and digital impressions can be sent to an external lab through the E4D Sky network.

3M ESPE developed Active Wave front Sampling (AWS) for its original intraoral scanner, the ***Lava C.O.S. AWS*** uses blue light detected by sensors at different angles and compares image focus on each sensor to determine 3D perspective. Lava C.O.S. has been replaced by the True Definition Scanner, which also operates by using AWS to capture 20 frames of video imagery per second. The images are converted to 3D data sets and displayed in real time as the 3D model on the computer screen. This system requires a light dusting of powder. A major improvement of the True Definition Scanner is the smaller intraoral wand, which contains a series of lenses fixed with an imaging sensor (Kravitz, ,2015).

The iTero system uses a parallel confocal system, in which light is filtered by passing through a small pinhole. Only the light reflected from the object at the proper focal distance will pass back through the pinhole. The iTero system also uses a telecentric system to maintain the same field of view of the area being scanned regardless of distance from the object that is being imaged. As a result, there is no need to hover the scanner above the object being scanned, and the scanning probe can be placed directly on the surface of the teeth being scanned. Additionally, no reflective coating powder is applied to the oral cavity(Baheti,2015).

The IOS FastScan is one of the newest intraoral scanning systems. This device operates by projecting a red laser sheet, which moves along with a camera within the wand. This technology allows a large scanning area to be captured with only three positions (buccal, lingual, and occlusal). The FastScan uses a powder and the wand can be placed directly on the tooth surface(Kravitz *et al* ,2015).

Each scanning system offers benefits that determine convenience for individual practitioners, including the size of the wand, use of powder, method of scanning (hovering above tooth or resting on tooth), ability to capture color, ability to capture full-mouth scans, method of obtaining intra-occlusal record, ease of using software, portability of device, and time/scans required for scanning. After scanning, the final prostheses can either be fabricated directly (in-office or lab milled) from digital information or indirectly (cast or pressed) from a resin model. Each company determines if the digital impression can be sent directly to the lab in an STL (stereolithography or "send-to-lab") file or must be sent to the company first, and if a fee is applied(Baheti,2015).

11.4 Value of Digital Impressions

Digital impressions offer advantages to both the clinician and the patient. For clinicians, digital impressions may reduce laboratory remakes because the computer screen image of the prepared teeth is magnified, improving the view of the preparation quality. If defects or inadequate preparation reduction are noted in the preparation, that area may be rescanned rather than making another impression as with conventional impression techniques. Additionally, digital impression devices measure the occlusal clearance between the prepared and opposing teeth and allow the dentist to make changes, if required, before sending the impression to the laboratory.

Another major advantage of digital impression systems is their ability to stop the imaging process at any time and continue, which allows the dentist to remove blood and saliva and then continue scanning. The accuracy and durability of the model produced by some digital systems is another significant advantage. Made of resin, they are significantly more abrasion-resistant and precise than gypsum models. Another advantage of digital systems is that the laboratory prescription accompanies the digital impression file and is completed before making the digital impression(Kravitz,*et al* ,2015)..

These devices are also extremely patient friendly. They eliminate the uncomfortable, messy impression-taking process, which causes some patients to gag. They also shorten prosthesis delivery time, because Internet transfer of the file and reduced laboratory procedures shorten the total prosthesis fabrication time. Finally, there is the “wow factor” that occurs when the patient sees the digital impression on the screen for the first time.

Digital impression systems do have some disadvantages. Digital impressions require that the entire margin is exposed along with 0.5 mm of tooth structure apical to the margin to ensure a favorable emergence profile. Digital impression taking is also associated with a significant initial cost investment, an operating learning curve, and a cost for processing the digital impression. Also, the wand size can be a problem for patients with restricted opening.

11.5 Comparing Accuracy and Efficiency

Several studies have compared the clinical success and accuracy of digital impressions to conventional impressions. These studies demonstrate that impressions, models, and crowns fabricated from digital intraoral scanners were equally or more accurate than those produced from traditional impression materials.

The idea that digital impression may be faster is controversial. Although the 3-to-5-minute scanning process requires roughly the same amount of time as traditional impression materials setting time, there is no need to select a tray, apply tray adhesive, clean impression trays, assemble impression guns and tips, or disinfect impressions(Kravitz,*et al* ,2015).. Another timesaving feature of a digital impression is that a portion of a deficient area may be rescanned with the digital system rather than retaking the entire impression. Lee and Gallucci reported that the total treatment time for iTero digital impressions of single implant restorations was approximately half the treatment time of a traditional impression. A controlled double-blind clinical study by Givan et al reported no difference in 50 crown margins made from digital and conventional impressions. This study reported significantly higher impression time with iTero-produced digital impressions (8 minutes, 40 seconds) compared with fast-set traditional impressions (4 minutes, 23 seconds); however, conventional impression set-up and clean-up time were not included.

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