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Review Article

Gingival Retraction Methods for Fabrication of Fixed Partial Denture: Literature Review

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Abstract

Fixed dental prosthesis success requires appropriate impression taking of the prepared finish line. This is critical in either tooth supported fixed prosthesis (crown and bridge) or implant supported fixed prosthesis (solid abutment). If the prepared finish line is adjacent to the gingival sulcus, gingival retraction techniques should be used to decrease the marginal discrepancy among the restoration and the prepared abutment. Accurate marginal positioning of the restoration in the prepared finish line of the abutment is required for therapeutic, preventive and aesthetic purposes. In this article, conventional and modern methods of gingival retraction in the fixed tooth supported prosthesis and fixed implant supported prosthesis are expressed. PubMed and Google Scholar databases were searched manually for studies on gingival tissue managements prior to impression making in fixed dental prosthesis since 1975. Conclusions were extracted and summarized. Keywords were impression making, gingival retraction, cordless retraction, and implant. Gingival retraction techniques can be classified as mechanical, chemical or surgical. In this article, different gingival management techniques are discussed.

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Introduction

Several factors affect the success and durability of restorations. In general, the type of impression making, setting accuracy, material flow, temperature, humidity, mixing, disinfection and pouring time have effects on the final accuracy of the indirect restorations. Supra-gingival margins are effective in periodontal health maintenance, but do not provide optimal aesthetics. So in most cases especially in aesthetics zone, the margin of the restoration is placed sub-gingivally. In tooth supported and implant supported fixed prosthesis, impression making requires accurate record of the prepared finish line area, especially in cases where the prepared finish line is located at same level of gingiva or sub-gingiva [1-3]. The gingival margin should be clean and available during impression making, allowing adequate flow of

the impression material on it. Gingival sulcus must also be wide enough. Accurate impression is usually achieved with the sulcular width of 0.15 to 0.20 mm. If the sulcus width is less than this value, impression material is unable to resist against the rupture and deformation, thereupon the impression marginal accuracy is reduced. The primary factor in defective record of marginal details is due to the inefficacy of the gingival displacement technique [2]. In the present study, articles involving various gingival displacement techniques, recording accurate finish line and its effect on impression procedure are discussed.

Search strategy

Related articles on gingival management methods before impression making of the fixed prosthesis were obtained by manual searching from databases as Pub Med and Google Scholar from 1975 to 2015, then summarized and analyzed. Keywords included impression making, gingival retraction and cordless retraction.

Ideally, the retraction technique choice must be simple, quick, and inexpensive and should not cause damage to periodontal tissues. There are a variety of retraction methods including retraction cords with and without medication, rotary curettage, copper band, rubber dam, electro surgery, laser and some types of polymeric and plastic materials [4,5].

Discussion

Gingival displacement comprises bending the gingival margin far from the tooth surface which provides adequate horizontal and vertical space between the prepared finish line and gingiva to inject sufficient amounts of impression material [1,6-10].

Four forces such as retraction, relapse, collapse and displacement have a role in displacing the periodontal tissue [5,11]. Elasticity of the gingival cuff and rebound of the adjacent attached gingiva are effective in the relapse [1,12]. During retraction in the natural teeth, well differentiated periodontal fibers support the gingival fibers and partially reduce the tissue collapse after removing the retraction agent [5,12]. After preparing the finish line of the abutment tooth, the marginal gingiva is displaced to control the bleeding, gingival fluid flow and more penetration of the impression material. There are three general methods for gingival displacement including mechanical, chemical and surgical methods which can be used separately or in combination [2,5,12]. Gingival displacing (retraction) agents must have the following characteristics:

A-Effectiveness: It causes significant horizontal and vertical gingival recession and controls bleeding and gingival fluid flow. B-Retraction: The agents applied do not make up certain permanent damage in adjacent tissues. Any manipulation and chemical tissue treatment result in damage to some extent. However, this damage must be reversible and recover within 2 weeks clinically and histologically. Maximum apical recession following the gingival retraction should not exceed 0.10 mm. C-Absorption of the retraction agents into the surrounding tissues must not cause systemic effects. The amount of reabsorbed material depends on the type of retraction agents, tissue ulceration and the amount of prepared tooth abutments [13].

This study aims to express all the mentioned methods in tooth supported and implant supported fixed prosthesis.

Gingival retraction in the fixed partial dentures

Mechanical retraction

The most common method in gingival retraction which is fast, simple and inexpensive is cord packing that can be used separately or in combination with hemostatic agents in two techniques: single cord or dual cord [14]. Retraction cord penetration depth is influenced by the sulcus depth and periodontal status. In dual cord technique, two knitted cords with different diameters are used. The apical cord is thinner and is kept in place during impression making. Thus a trough is made around the preparation area and gingival cuff recoil is delayed [15]. However, using the mentioned method is limited in supra-gingival preparation margins [16]. Unpredictable tissue resorption and patient's discomfort are problematic issues associated with Dual Cord technique [5,15]. One cord is used in Single Cord method which is removed before impression making. If the preparation finish line is deep at the sulcus, the soft tissue collapse prevents accurate impression making [15,16].

Feng *et al.* revealed that tumor necrosis factor alpha (TNF-α) level increases followed by cord packing causes Sulcular epithelium and connective tissue attachment damage; however, complete clinical improvement occurs within 2 weeks [17]. Cord filament remnants and improper cord packing force may be associated with the sulcular inflammation

and marginal gingiva contraction [18]. Retraction cords require high technical sensitivity and clinical skill [3]. Non-medicated Simple cords are safe but it is not a proper option to control bleeding. Cord pressure cannot stop the gingival bleeding by itself [19] and in more than 50% of cases bleeding occurs after removing the cord [5]. A simple way to reduce bleeding is moisturizing the cord [5]. To prevent the rupture and deformation of silicon impression materials, the sulcus width must be at least 0.2 mm, so the retraction agent is needed to be located in the sulcus for at least 4 minutes [5,7,9].

Serrated round end cord packing instruments are generally used with braided cord since small indentations in the instrument's head sink in the cord and prevent the instrument slippage and further trauma to the epithelial attachment. Non-serrated flat end instruments are applied in twisted cords with sliding motion [5,14]. It is suggested that one kind of copper reinforced retraction has easier placement [20].

Chemical retraction

There are three types of chemical retraction.

a-Vasoconstrictive agents, b-Hemostatic agents, c-Astringent agents

Great Britain Pharmacology Research Center explains these agents as follows: [21,22]

-Vasoconstrictive agents are not coagulated like epinephrine but act out constricting and reducing the blood vessels' diameter. Impregnated cord with racemic epinephrine has no advantage over other retraction agents, due to increased blood pressure and heart rate [22,23].

-Hemostatic agents control severe bleeding from arterioles and cut vessels [22].

-Astringent agents such as alum, aluminum chloride and zinc chloride are metal salts that inhibit plasma proteins' inter-capillary immigration, decrease cell permeability, control the moisture in the peripheral tissues through protein precipitation on the superficial layer, and increase the mechanical strength of the mucosa. Thus, protein precipitation has hemostatic effects under physiological condition. For example, ferrous chloride and ferric sulfate are concentrated astringents which make superficial and topical coagulation. However, it should be noted that denatured proteins can be involved in topical tissue destruction [2,24,25]. Aluminum chloride and ferrous sulfate are the preferred astringents in dentistry owing to minimal tissue irritation, ease of use and satisfactory results [22,26]. Chemical agents without mechanical retraction have less efficiency in the pockets deeper than 2 mm [2,27].

Epinephrine and Sympathomimetic agents

It is a common retraction agent that provides good hemostasis and vasoconstriction. It has localized hemodynamic effects [28] and causes tissue ischemia by activating sympathetic peripheral vascular α1 receptors. Localized vasoconstriction produces temporary gingival retraction [25,29]. However, its side effects limit its use. Maximal permissible dose of epinephrine in healthy ones is 0.2 mg and in patients with cardiovascular disease is 0.04 mg; this is equivalent to the epinephrine that is in two local anesthesia cartridges containing epinephrine 1/100000 [13,30].

Epinephrine absorption depends on the gingival health. Kellam *et al.* reported that epinephrine absorption from the retraction cord is 64% to 94% [31]. Also, Madrid *et al.* reported that intact epithelium is an effective barrier against epinephrine binding to the plasma proteins [32]. Epinephrine use as a retraction agent aggravates the risk of overdose because a soaked thread contains 0.2 - 1 mg epinephrine depending on its diameter and length which is 2.5 times higher than the permissible dose for healthy subjects and 12 times higher than the permissible dose for patients suffering from cardiovascular disease [25].

Epinephrine is contraindicated in patients using β-blocker and antihypertensive drugs [29]. Epinephrine syndrome occurs in 33% of people and produces clinical symptoms like tachycardia, tachypnea, hyperventilation, hypertension, fatigue, anxiety and depression. Epinephrine is a myocardial stimulator, so its overdose can cause ventricular tachycardia, fibrillation, angina, and heart and brain infarction. Epinephrine should not be used as a retraction agent in patients suffering from hypertension, depression and are treated with mono amine oxidase (MAO) inhibitors [33]. Epinephrine absorption can increase the blood glucose level in diabetic patients [13].

Sudden increase in the epinephrine level after a stressful dentistry session can be seen even in healthy people. If the local anesthesia containing vasoconstrictor and retraction agent containing epinephrine are used simultaneously, additive effects occurs. In general, it is recommended that epinephrine use as a retraction agent should be restricted. The only advantage of epinephrine compared to astringents is its ability to control bleeding [2,30].

The preferred vasoconstrictive material has sufficient efficiency without systemic and local side effects [34]. Systemic reaction is rare in some of the alpha agonists' vasoconstrictor materials such as tetrahydrozoline and oxymetazoline that are often used as eye and nose decongestants drops. Therefore, a lower dose of the maximum allowed rate can be used in the gingival retraction. The study of Bowles *et al.* showed that tetrahydrozoline is a strong retraction agent without any systemic side effects. The study of Tardy *et al.* showed that tetrahydrozoline is better than epinephrine in gingival retraction [2,24].

Ferrous sulfate

It has a concentrated solution to coagulate bleeding finish line and can act as an effective astringent. Within a few days (1-2 days), it can cause temporary gingival discoloration yellowish brown and black [35]. Utilization of this compound has been controversial in implants, because it can delay the setting time of the polyether and polyvinyl siloxane impression material [36]. Complete rinse out with copious water is recommended to remove the excess material. Conrad *et al*. reported that in the case of using ferric sulfate retraction agent in the ceramic translucent restoration, black internal dentin discoloration and patient dissatisfaction occur [37].

An in vitro study showed that dentinal exposure with a strong acidic ferric sulfate can remove the smear layer during 30 seconds [38]. This material has a negative effect on bonding the self-etch adhesives, thereupon marginal discoloration by microleakage is justified [5,39]. Acidic compounds of ferric sulfate 15% can make severe tissue irritation and postoperative hypersensitivity. Usually, homeostasis is achieved within 1-3 minutes [40] and opens the sulcus wide for at least 30 minutes [21]. Ferric sulfate tissue irritation is much more than aluminum chloride [41]. Nowakowska *et al.* compared the cytotoxicity of the astringent retraction agents and expressed that ferric sulfate, aluminum chloride, and aluminum sulfate have the least toxic effects on human gingival fibroblasts, respectively [42].

Ferric sub-sulfate

Also called Monsel solution develops the gingival retraction within 3 minutes [43]. Greater gingival displacement and favorable tissue recovery is achieved compared to epinephrine. Soft and hard tissues discoloration may occur to acidic and corrosive properties of ferrous salts [22].

Zinc chloride (bitartrate)

It has a burning effect and may cause soft and probably hard tissues scar; as a result, both 8% and 40% concentrations are not recommended [22,43].

Tannic Acid

The recommended time is 10 minutes. It has less hemostatic effects Compared to epinephrine, but tissue recovery is better [22].

Negatol Solution

It is a strong acidic substance, a mixture of 45% metacresol sulfonic acid and formaldehyde that may decalcify the tooth structure [22].

Aluminum sulfate and aluminum potassium sulfate (alum)

They are both hemostatic agents that inhibit inter-capillary plasma proteins immigration and disrupt bleeding through vasoconstriction and precipitation of tissue proteins on the superficial layer of the mucosa [23]. Postoperative inflammation is slightly low in concentrations to the extent of treatment levels. Aluminum potassium sulfate at high concentrations can cause severe inflammation and tissue necrosis [5]. Its tissue contraction in a concentration of 100% is less than epinephrine in a slight difference. It has limited effect on the gingival retracting, but as an alternative to epinephrine it is safe and effective. The important thing is that sulfate compounds may inhibit or delay the polymerization reaction of the additive silicone impression materials [22].

Aluminum chloride

It is an astringent that acts by precipitation of tissue proteins and vascular constriction. Its vasoconstrictor effects are less than epinephrine [24]. Among the medical impregnated cords, it creates the least irritation [17]. It has been usually used in 5. 25% concentrations and has little systemic effects [22]. Its fundamental flaw is inhibition of polyether and polyvinyl siloxan material [36]. After removing the cord, it keeps the sulcus open longer and acts more effective than epinephrine (50% of the sulcus width is closed after removal of the cord impregnated with epinephrine at the same time while the sulcus which

are retracted by the cord impregnated with aluminum chloride, 80% of the its first width will remain open after 12 minutes [9]. Before impression making, remnants of aluminum chloride must be well rinsed up not to interfere with the perfect setting of polyvinyl siloxane [43].

Chemicomechanical retraction

It is the most common method used by almost 80% of dentists. To prevent bleeding during cord packing and impression making, hemostatic agents can be used simultaneously [30]. Epinephrine, aluminum chloride and ferric sulfate are usually used as pre-treated retraction cord or impregnating simple cord [44]. The use of aluminum chloride is more common than epinephrine. In one study, 33% of the participants showed side effects to epinephrine and 24% had side effects to other retraction agents [14]. Removing aluminum chloride and ferrous sulfate impregnated cords causes bleeding due to hyperemia, but epinephrine provides optimal homeostasis by long-term constricting gingival capillaries [44].

However, epinephrine has the risk of drug interactions in cardiovascular disease patients [27]. Comparing two cordless retraction techniques" Expasyl and Korlex GR" with Ultrapak cords showed similar gingival deflection, but Ultrapak cords were more painful and made more gingival recession [45]. In 2014, Sarmento *et al.* evaluated the cordless and cord retraction techniques. Both methods are similar in terms of pain and increasing the periodontal index; just psychological stress is less in cordless retraction methods. Also, fewer inflammatory cytokines are released in cordless methods compared to cord packing methods [41]. In 2012, Bennani *et al.* compared the pressure generated from cordless methods to Knitted cords. Expasyl injection generated the least pressure and its pressure will be less in reuse [46].

Polymers and pastes

Recently, polymers and pastes have been introduced in gingival retraction. Two millimeters prepared spongy tapes made from polymeric materials are swelled in contact with moisture and slowly provide enough space between the gingival sulcus and prepared finish line. Gingival recovery happens slowly within 24 hours [47]. For example, Merocyl strip is effective in gingival tissue expansion to expose the prepared finish line [48]. The strength of epithelial attachment is 1 N / mm. Very low 0.01 N / mm pressure will cause the sulcus to open and quick recovery happens. Pressure of 0.1 N / mm makes the sulcus open at 1.5 mm limit and delays the recovery to 2 minutes per 0.5 mm opening. Paste infusion into the gingival sulcus provides constant and non-destructive pressure of 0.1 N / mm. If the paste remains in place for 1 minute, enough pressure to open the sulcus 0.5 mm will be achieved within 2 minutes [49].

Expasyl paste material provides high hemostasis and a little gingival retraction and is a chemical agent in an injectable matrix that may be applied in impression making and delivery of indirect restorations. It must be isolated to the saliva during application. Expasyl paste contains aluminum chloride 15% as a hemostatic agent and White Clay for consistency and is injected directly into the gingival sulcus [4,5]. Moreover, it can be compressed into the gingival sulcus via a plastic instrument or cotton pellet. If the soft tissue biotype is thin, the paste remains in place for 1-2 minutes and if it is thick, it remains for 3-4 minutes. Retraction effects remain 4 minutes after thorough rinsing with air and water. Disadvantages are greater cost, inhibiting polymerization of polyether and polyvinyl siloxane impression materials. It is also less effective in sub-gingival positioned deep margins [5]. But it is a simple, fast and painless method which doesn't create any chemical reaction, tissue inflammation and trauma. Compared to traditional methods, possible risk of tissue trauma to the epithelial attachment, gingival recession and bone loss is avoided [50].

Gingi Trac paste is an astringent agent, generally used in hemostasis and gingival retraction. To increase the width of the retraction, a cap for single unit prepared tooth or a stock tray containing the matrix of firm paste for multiple unit prepared teeth can be used for 3-5 minutes [5].

Inert Matrix Poly Vinyl Siloxane system introduced Magic Foam Cord paste material for gingival retraction which contains expandable polyvinyl siloxane. Setting expansion of the material against gingival sulcus wall is achieved by hydrogen dioxide release [4]. It provides some amount of homeostasis, but prior to injection it is essential to use hemostatic agents separately. Increasing the width of the retraction is recommended to bite on a cap about 5 minutes to compress more paste into the sulcus. This is a simple, fast and painless system which has no chemical reaction, inflammation, and tissue trauma. However, it is less effective in sub-gingival margins [5]. Expasyl and Magic Foam Cord resulted in less tissue destruction compared to other methods [22]. In 2009, a study conducted by Beier US *et al.* revealed

that Magic Foam Cord is effective in epi-gingival and sub-gingival prepared margins less than 2 mm; however, in bevel and sub-gingival prepared margins, single cord is much more efficient to Magic Foam Cord [27]. In 2013, Gupta *et al*. evaluated horizontal and vertical retraction characteristics of Stay put cord, Magic Foam Cord and Expasyl and reported that Magic Foam Cord material had the greatest effect [20].

Matrix impression making

In 1983, Livaditis introduced a system that required impression using three different viscosities of the material [11]. In this method, at first an occlusal matrix of elastomeric material (semi rigid consistency) is provided from the prepared teeth and trimmed in certain dimensions; then, cord packing is done as the usual way. After removing the cord, final impression is done using high viscose matrix of the preparation; in other words, gingival retraction is achieved from precise placement of the high viscosity matrix material. Maintaining the matrix impression in place, full arch pick-up impression is done using a stock tray containing medium viscosity material. This technique can control four forces affecting the gingiva during sub-gingival impression. Sulcular debris is removed. Matrix design prevents the collapse of the gingival margin and tearing of the impression material by pressing high viscosity material into the sulcus. The only problem with this method is the increase in chair side time [5].

Surgical Retraction

Rotary curettage

A trough is prepared with a diamond bur in the gingival sulcus adjacent to the finishing line area, following the administration of local anesthesia. The height of the marginal gingiva is approximately preserved but the sulcus gets deeper. This method can be used only if adequate keratinized gingiva is available. Trauma to the epithelial attachment may cause gingival recession due to exacerbated inflammatory response [5,51].

Electrosurgery

Following local anesthesia, passing the electric current through a thin wire can prepare a trough in the gingival sulcus adjacent to the finishing line; also, hemostasis is achieved. Moving a small J-Shaped electrode parallel to the tooth long axis can increase the sulcus width [52]. Comparison of the electro-surgery with rotary curettage showed no difference in tissue response within 4-12 weeks [53]. The sulcular volume of the impression material was greater in electro surgery compared to the rotary curettage [53]. Electro surgery is contraindicated in patients with cardiac pacemakers. It has a high risk if used with Nitrous oxide [5,52,53].

Laser

Laser can be used for gingival retraction in either direct or indirect restorative treatments. Laser characteristics depend on the wavelength and waveforms. Laser is a high powered focused beam which causes tissue vaporization in 100°C -150°C [54]. Laser induced tissue retraction is a kind of trough allowing to make precise impression with biological width preservation. It provides great homeostasis and can be applied without any localized anesthesia. It has minimum postoperative pain and discomfort [5,15].

Er-based and Nd: YAG lasers energy is absorbed into the superficial and deep tissue layers, respectively [55]. Usually in natural dentition, retraction is done by diode laser as it has less bleeding and gingival recession [15]. YSGG Laser (Water lase) is useful in either soft or hard tissue surgical interventions [56]. Co2 laser has greater hemostatic effect than Er: YAG laser, but it does not make any tactile feedback; therefore, junctional epithelium injury is possible [54]. Unlike Dual cord technique, lasers prevent tissue recession . Comparison of the Pulsed Nd: YAG lasers to retraction cord impregnated with ferric sulfate or aluminum chloride revealed that bleeding and tissue inflammation are lower, but healing rate is greater [15].

Gingival retraction in implant supported prosthesis

The use of implant-related treatment modality has increased recently. Cement retained restorations are preferred to screw the retained restorations. Custom abutments with subgingival margins are useful in aesthetic regions and minimal inter-arch space [57]. Emergence profile of the abutment prevents pickup impression in the cement retained prostheses, but the resemblance of impression copings to the manufactured final abutment in screw retained implant allows the operator to make pick up impression [4].

Tissue support of the implant is not similar to the periodontal structure, so tissue collapse is not restricted following gingival retraction. In implants, the poorly adherent, permeable junctional epithelium has low regenerative capacity. The gingival fibers are parallel to implant collar and biologic width is 2.5

± 0.5 mm [4]. Collagen fiber orientation is parallel or parallel-oblique [58]. Soft tissue biotype is also effective, i.e. thin fragile periodontal biotypes should be managed gently to prevent recession while more often a pocket is formed in thick fibrotic biotypes [5,59].

Mechanical retraction

Mechanical retraction techniques may be contraindicated around the implants, except for shallow sulcus depth and a thick periodontal biotype [4]. Microscopic scratches on the implant collar and then biofilm aggregation might occur to traumatic application of packing instruments [5,60].

Injectable matrix

The retraction force is limited due to high viscosity of the matrix, preventing the sulcus from trauma, but efficient retraction is not obtained especially when the relapsing and collapsing forces are important. Biologic width is greater in dental implants compared to natural teeth, i.e. in aesthetics region the implants are deeply placed [5].

Rotary curettage, Electrosurgery, Laser

Rotary curettage has a high risk to scratch the implant surface and exposure of implant threads. Electro-surgery is contraindicated in implants (arcing happens). Unlike other lasers, prime chromphore for CO2 laser is water. Therefore, it reflects off metal surfaces. CO2 lasers absorb little energy near the metallic implant surfaces and temperature increases less than 3°C. Also, these lasers do not alter the implant surface properties. Lasers expose the implant margins by creating a trough. Therefore, its application around the deep implants creates large defects. Indeed, it is questionable in anterior, aesthetics regions [5,61].

G- Cuff

There are challenging techniques to record subgingival contour of the abutment. Comparison of the implants to the teeth showed that there was not a special technique to retract the gingiva before impression making. Chang *et al*. [62] evaluated the effects of cordless retraction material (Expasyl) on the implant surface and found that minimal changes occurred. Wide healing caps or temporary abutments which are used in some kinds of implant systems (e.g. Bicon) have not predictable results due to various tissue rebound. G-Cuff™ is an impression device that is claimed taking an accurate registration of a dental implant abutment.

The main purpose of G-Cuff is to support the soft tissue that surrounds the implant abutment. So it retracts the gingiva to allow the impression material or digital intra-oral scanner recording the implant abutment, so the final restoration can be accomplished within two visits. The instructor claimed that the restoration using G cuff is more accurate than open tray and close tray impression techniques [4]. It is helpful for unidentified dental implants and eliminates the need to transfer the copings and analogs. It is not traumatic for the soft tissue unlike retraction cord [63]. However, more studies are recommended to verify its efficiency. Further research is recommended, especially on abutment level impressions.

Conclusions

Gingival retraction techniques can be classified as mechanical, chemical or surgical. In this article, different gingival management techniques comprising non-medicated cords, medicated cord, cordless techniques, astringent hemostatic agents, gingival retraction paste, vasoconstrictive agents, lasers, rotary curettage, electrosurgery were discussed. Also, gingival retraction in dental implants and digital impression were discussed.

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