ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at: www.ijdsir.com

Volume – 4, Issue – 4, July - 2021, Page No. : 362 - 373

Comparative assessment of gingival retraction using merocel and lasers in intraoral digital impressions

[1]Dr. Rakshitha Rao, Department of Prosthodontics, V.S Dental College and Hospital, Bangalore

[2]Dr. Surendra Kumar G.P, Head of the Department, Department of Prosthodontics, V.S Dental College and Hospital, Bangalore

[3]Dr. Archana Shetty, Reader, Department of Prosthodontics, V.S Dental College and Hospital, Bangalore.

[4]Dr. Bharath Raj, Reader, Department of Prosthodontics, V.S Dental College and Hospital, Bangalore.

Corresponding Author: Dr. Rakshitha Rao, Department of Prosthodontics, V.S Dental College and Hospital, Bangalore

Citation of this Article: Dr. Rakshitha Rao, Dr. Surendra Kumar G.P, Dr. Archana Shetty, Dr. Bharath Raj, "Comparative assessment of gingival retraction using merocel and lasers in intraoral digital impressions", IJDSIR- July - 2021, Vol. – 4, Issue - 4, P. No. 362 – 373.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Background: Various methods of tissue management such as mechanical, mechanico- chemical methods, electrosurgery, rotary gingival curettage have been applied to achieve gingival retraction. Merocel is an absorbing, hemostatic material commonly used for nosebleeds. It is a synthetic, chemically pure material extracted from a biocompatible polymer (hydroxylate polyvinyl acetate) that creates a net like strip without debris or free fragments. Soft tissue diode lasers at a wavelength of 980 nm are used for gingival retraction. Lasers provide hemostasis and reduced tissue shrinkage. The objective of this study was to assess and compare the amount of lateral gingival retraction achieved by merocel and soft tissue diode laser using intraoral digital impressions.

Methodolgy:15 patients were selected for the study after an informed consent form was obtained. Premolars were prepared to receive an all ceramic crown. Following tooth preparation, merocel was cut into 2mm thick strips and inserted around the gingival sulcus using a cord packer. A temporary crown was placed over the prepared tooth, a cotton roll was placed over it and patient was asked to bite on it for 10 minutes. An Intraoral digital scan recorded the amount of gingival retraction after retraction with Merocel.The patient was recalled after a week and the temporary crown was removed. Gingival health was assessed and gingival retraction was performed on the same tooth with soft tissue diode laser under continuous mode and at 2.2 watts. Another digital impression was made to check the amount of gingival retraction with lasers. 3 shape software was used to measure the amount of gingival retraction at four points around the tooth namely midfacial, mesial,distal and palatal. Paired t test was used to arrive at the results and the level of significance was kept at 0.5.

Results: The average amount of gingival retraction achieved by merocel and laser in the mid facial region was 0.84 and 0.71, in the mesial region it was 0.84 and 0.70, 0.79 and 0.68 in the distal region and 0.78 and 0.71 in the palatal region respectively.

Conclusion:Thus it was concluded that the mean amount of gingival retraction achieved by merocel was greater than laser in the midfacial ,mesial,distal and palatal regions.

Keywords: Gingival retraction ,Intraoral Digital impressions, Merocel, Soft tissue diode lasers.

Introduction

The ultimate goal in fixed and removable prosthodontics is the maintenance and preservation of the remaining dentition. Restoration of teeth is possible only if sufficient space is created for the application of the appropriate thickness of material required. Preparation of a finish line allows ample room for the periodontal tissues and the bulk of the restorative materials[1]. Indirect restorations are routinely used to restore defective teeth. These restorations frequently have cervical margins that are intentionally placed in the gingival sulcus for esthetic or functional reasons. In these situations, the clinician must make impressions that accurately capture the prepared cervical finish lines and permit the fabrication of accurate dies on which the restorations are fabricated[3].

The goal of gingival retraction is to atraumatically displace gingival tissues to allow access for impression material to record the finish line and provide sufficient thickness of gingival sulcus so that the impression does not tear off during removal. A minimum bulk of 0.2-mm thickness in the sulcus area has to be maintained to make an undistorted impression with polyvinyl siloxane impression materials. Hence gingival retraction exposes the prepared margin and unprepared tooth structure to impression material[4].

Techniques for gingival displacement have been classified as mechanical, chemical, surgical, and combinations of the three. The method of gingival displacement used by the majority of practitioners is a combination of mechanical-chemical displacement using gingival retraction cords along with specific hemostatic medicaments[7].

Advanced digital technology is changing what is possible in oral health, function and aesthetics. With digital technology it is possible to capture accurate impression data more quickly and accurately than conventional dental impressions. Digital impressions 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.

For digital impressions, it is important that the retraction material does not leave behind any debris as it would distort the impression. The retraction cord and other materials used in retraction leave debris. Conventional method of cord retraction is a very time-consuming procedure because a significant amount of time may be spent positioning the cord properly when making impression of multiple abutments. Leaving the retraction cord for an extended time, especially when an impression is being made for multiple abutments, may cause damage to gingiva, postoperative discomfort and gingival recession. Sometimes, removal of retraction cord before impression making may cause bleeding of gingiva[9].

Gingival retraction using lasers can be done as lasers produce minimal damage of collateral tissues, reduce tissue shrinkage and gingival recession. There is comparatively less pain and the sulcus is also sterilized. Soft tissue diode lasers are indicated to achieve gingival retraction[10,11]. Use of diode lasers for retraction purposes has shown less recession around natural teeth as compared to retraction cord (2.2 percent versus 10.0 percent) with laser[23]. Retraction studies have shown bacterial reduction

at treatment site and improvement in gingival marginal health after 1 week. Thus, the use of diode lasers facilitates soft tissue management during impression making and serves as a valuable tool for the prosthodontist during the fabrication of accurate fixed prostheses.

Merocel is an absorbing, hemostatic material commonly used in otorhinolaryngic, gastric, thoracic, and otoneurosurgical procedures.It is relatively atraumatic for the patient. It displaces the gingiva with no tissue injury before making impression. Merocel retraction strips are of a synthetic material, which are specifically chemically extracted from a polymer hydroxylate polyvinyl acetate that creates a net-like strip without debris or free fragments. Placement of Merocel retraction technique does not require use of local anaesthesia. It also provides excellent gingival retraction compared to conventional retraction cords. The porous and sponge-like microstructure of Merocel produces a dry field for the impression to accurately capture the details. The absence of fibres decreases the risk of postoperative problems. Gentle tissue management with merocel allows a predictable healing and gingival height recovery for long-term esthetic results.

Thus this study intends to compare gingival retraction performed with soft tissue diode laser with a new biocompatible material Merocel. Digital impressions will be made to assess the amount of lateral gingival retraction.

Materials and methodology

1.Informed consent form

15 patients whose ages are above 18 years requiring fixed prosthesis for premolars were selected after obtaining an informed consent. It was ensured that all patients selected had healthy periodontium, absence of plaque and no bleeding on probing.

2.Tooth preparation of premolars

Tooth preparation of premolars was done to receive an all ceramic crown by following principles of tooth preparation and avoiding injury to gingival tissues. Initial tooth preparation of premolar teeth was done with a flat end tapered diamond bur (TF-12), the proximal walls were reduced using a short needle diamond bur (TF-20) and the final finishing was carried out using finishing burs (TF-12EF).

3.Fabrication of temporary crown

Prior to the start of tooth preparation procedure, a putty impression of the tooth was made. An alginate impression was made to prepare a check cast on which a temporary crown was fabricated by using Bis acryl composite resin (Cool Temp).

4.Gingival retraction with merocel

The prepared tooth was isolated and Merocel retraction material of thickness 2mm was cut according to the circumference of the tooth.The strip was inserted into the gingival sulcus around the tooth with the help of a cord packer (Stark cord packer GTX-30240). The temporary crown was placed on the tooth, a cotton roll placed over it, and the patient was asked to maintain pressure on the temporary crown and concomitantly on the merocel strip. This position was sustained for 10 minutes.

5.First Digital Impression

The material in the intracrevicular space was removed following which a digital impression was made. The distance between gingival finish line and gingival margin was measured at four reference points namely mesiobuccal, midbuccal, distobuccal and midpalatal regions using 3 shape digital software.

6.Cementation of temporary crown and recall

Temporary crown was placed on the tooth and the occlusion was checked to eliminate high points. This temporary crown was then cemented on the tooth with non-eugenol cement (Temp bond-Kerr Dental). The

patient was recalled a week later. The temporary crown was removed followed by periodontal evaluation to ensure a plaque index of zero, gingival sulcus depth between 0.5-2mm, normal contour of the gingival margin and no bleeding on probing.

7.Gingival retraction with lasers

Gingival retraction was performed on the same prepared tooth one week later with soft tissue diode laser (AMD lasers, Picasso lite by Dentsply). 2ml of Local anesthetic (lignocaine) was administered around the tooth and all the safety precautions for use of lasers like safety goggles for the patient were undertaken. The laser tip was passed around the gingival sulcus to cut the gingival fibers. The laser operation mode was continuous pulse at 2.2 watts with an initiated tip.

8.Second digital impression

A second digital impression was then made following gingival retraction with laser.

9.Measuring the amount of gingival retraction

The images obtained from the first and second digital impressions were converted into STL format and uploaded on 3 Shape Software. Using the measuring tools provided by the software, distance between gingiva and the finish line was measured along four reference points namely, mesiobuccal, midbuccal, distobuccal and midpalatal regions.

10.Statistical analysis: Data collected from the study was analysed using statistical package for social sciences [SPSS]. Based on the normality of data, student paired t test/ Wilcoxon singed rank test was used.

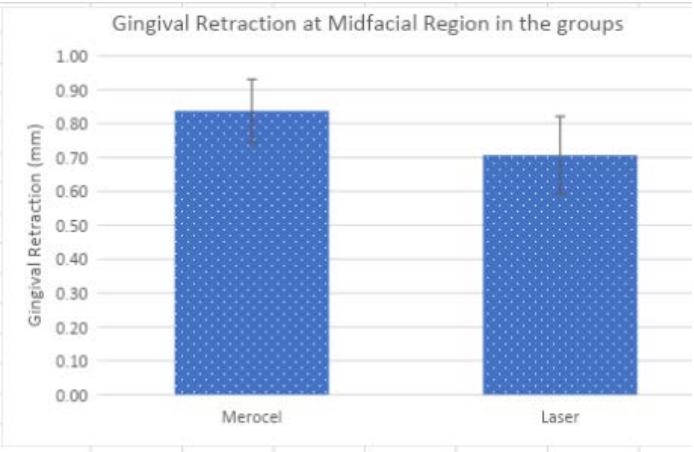
Results

In midfacial region, higher mean gingival retraction (mm) was recorded in Merocel method compared to Laser method. The difference between them was found to be statistically significant (P<0.01).

Comparison of gingival retraction (mm) in Midfacial Region:

Method	N	Mean	Std Dev	SE of Mean	Mean Difference	t	P-Value
Merocel	15	0.84	0.09	0.02	0.131	3.413	0.002*
Laser	15	0.71	0.11	0.03			

*denotes significant difference

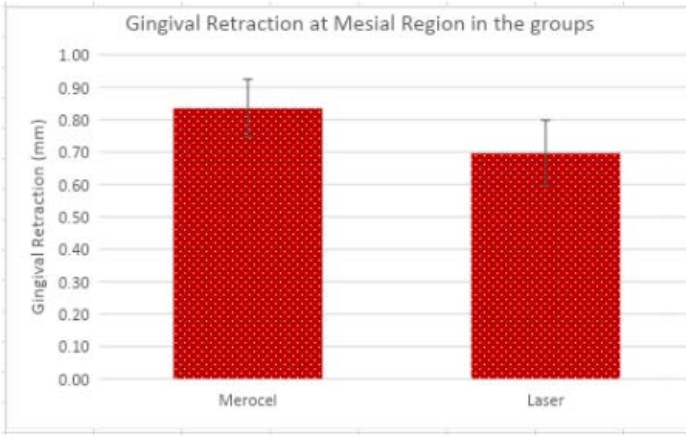


In mesial region, higher mean gingival retraction (mm) was recorded in Merocel method compared to Laser method. The difference between them was found to be statistically significant (P<0.001).

Comparison of gingival retraction (mm) in Mesial Region:

Method	n	Mean	Std Dev	SE of Mean	Mean Difference	t	P-Value
Merocel	15	0.84	0.09	0.02	0.139	3.957	<0.001*
Laser	15	0.70	0.10	0.03			

*denotes significant difference

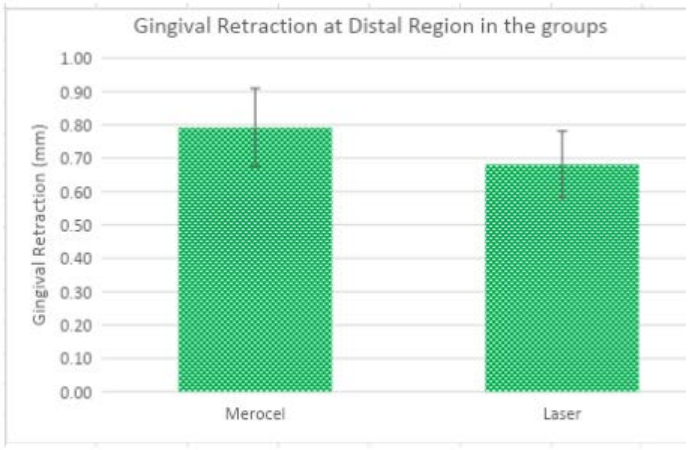


In distal region, higher mean gingival retraction (mm) was recorded in Merocel method compared to Laser method. The difference between them was found to be statistically significant (P<0.01).

Comparison of gingival retraction (mm) in Distal Region:

Method	n	Mean	Std Dev	SE of Mean	Mean Difference	t	P-Value
Merocel	15	0.79	0.12	0.03	0.111	2.776	0.010*
Laser	15	0.68	0.10	0.03			

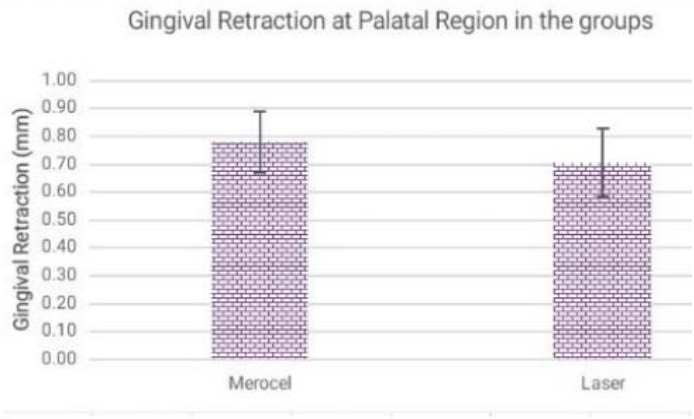
*denotes significant difference



In palatal region, higher mean gingival retraction (mm) was recorded in Merocel method compared to Laser method but the difference between them was not statistically significant (P>0.05).

Comparison of gingival retraction (mm) in Palatal Region:

Method	n	Mean	Std Dev	SE of Mean	Mean Difference	t	P-Value
Merocel	15	0.78	0.11	0.03	0.073	1.754	0.090
Laser	15	0.71	0.12	0.03			



Discussion

The goal for the management of gingival tissues and gingival esthetics is to maintain the normal appearance of healthy gingiva. Achieving this goal requires optimal health before treatment and minimal trauma during treatment. The objective of impressions and for fixed dental prostheses is to register the prepared abutments and finish lines accurately. For all impressionprocedures, the gingival tissue must be displaced to allow the subgingival finish lines to be registered3.The relationship between periodontal health and restoration of teeth is intimate and inseparable. For long term survival of the restorations the periodontium must remain healthy and for the periodontium to remain healthy, restoration must be critically managed in several areas so that they are in harmony with the surrounding periodontal tissue. Restorations play an important role in the ecological balance of plaque and maintenance of the periodontium1 Retraction is the temporary displacement of the gingival tissue away from the prepared teeth. The gingival margin should be clean and non-contaminated 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 will tear and deform , hence compromising the marginal accuracy. The primary factor in defective record of marginal details is due to the inefficacy of the gingival displacement technique.

Gingival retraction material is considered ideal if it has the following desirable properties.

1. Effectiveness: It must cause significant horizontal and vertical gingival recession and control bleeding and gingival fluid flow.

2. Retraction: The agents should not cause permanent damage in adjacent tissues. Any manipulation and chemical tissue treatment results 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.

3. 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.9After preparing the finish line on the abutment tooth, the marginal gingiva is displaced to control the bleeding, gingival fluid flow and more penetration of the impression material. Various gingival retraction methods are mechanical, mechanochemical, electrosurgery, rotary gingival curettage. The most commonly used method is the mechanochemical one. Use of the mechanochemical method leads to violation of biological width, causing bone loss and recession12. Studies on the chemicomechanical and purely mechanical cord retraction techniques have shown various degrees of necrosis and/or stripping of the gingival sulcus4.Gingival electrosurgery for crevicular troughing involves a considerable risk of producing permanent periodontal damage. Artzi et al studied the effects of electrosurgery, retraction cord, and the rotary gingival curettage technique clinically and histologically in dogs from 6 hours to 14 days.They concluded that all methods induced some kind of minor damage and recession of clinical magnitude was induced only by rotary gingival curettage. Liu et al studied the cytotoxic effects of gingival retraction cords impregnated with aluminium sulphate (GingiAid), DL-adrenaline HCl (GingiPak) and non-drug impregnated cord (Gingi-Plain). The results showed that cords soaked with epinephrine was the most cytoxic, followed by cord withaliminum sulphate. Plain cord showed the least amount of cytotoxic activity onfibroblasts9.All the methods tested induced some degree of destruction of sulcular epithelium and/or junctional epithelium as well as edema and disruption and/or loss of fibers in circumscribed regions of the underlying connective tissue. All the minor destructive changes seen in the initial time periods had repaired by 14 days. There was no evidence of cemental damage in any of the sections histologic studies confirmed trauma to sulcular epithelium and connective tissue attachment on placement of retraction cords either placed alone or in conjunction with other chemicals. Inflammation of the sulcus can get exacerbated due to contamination of sulcus wounds by residual filaments/fibers of the cord6 .Application of inappropriate amount of force while placing retraction cords can also contribute toward gingival inflammation and shrinkage of marginal tissues.

Plain cords, not moistened with suitable medicaments, are not a good choice for retraction, as the sulcular hemorrhage cannot be controlled just by the pressure applied by the cord on gingival tissues. More than 50% of the situations are associated with bleeding on removal of plain retraction cord, although wetting the cord before removal may play a crucial role in controlling bleeding from gingival sulcus. Retraction cord penetration depth is influenced by the sulcus depth and periodontal status. Thus a trough is made around the preparation area and gingival cuff recoil is delayed11.In this study, amount of lateral gingival retraction achieved by merocel strips and soft tissue diode lasers was compared by measuring the distance between gingiva and finish line at four different points using digital impressions and three shape software. According to the results of this study, the mean amount of gingival retraction in the mid facial region was 0.84 and 0.71, in the mesial region it was 0.84 and 0.71, 0.79 and 0.68 in the distal region and 0.78 and 0.71 in the palatal region for merocel and laser respectively. Indicating that the mean amount of gingival retraction achieved with lasers is much higher than the amount of retraction achieved with soft tissue diode laser.

Merocel strips demonstrated a fluid free, haemostatic environment. The haemostatic property might be attributed to the moderate pressure exerted by the material

placed in the sulcus and not because of the chemical composition6. The advantages of merocel include not requiring the administration of local anesthesia,merocel strips do not contain fibers so it does not leave behind any debris that can get embedded in the final impression. The gingival sulcus is clean without chances of postsurgical complication such as infections, blood clots and inflammatory reactions. Also, after removal of merocel, no bleeding was noticed in the gingival sulcus emphasising the fact that gentle tissue management is achieved. However, use of Merocel material as a gingival retraction device carries some drawbacks including the need for temporary crowns at the time of impression making itself because it is difficult to secure the material in place during the process of placement and retraction. Also, bleeding from the gingival sulcus must be controlled before placing merocel strips in the sulcus because merocel would absorb the excess blood and swell up too soon making it impossible to adequately place it in the sulcus. Merocel always requires a clean dry field with minimum bleeding and relatively healthy gingiva. The Diode laser was first used for dental procedures in 1995. Diode lasers are solid-state aluminum gallium arsenide (AlGaAs) semiconductor lasers, which efficiently convert electrical energy into coherent light energy. The diode laser has wavelengths of between 800 and 980 nm. This wavelength range is well absorbed by pigmented tissue and haemoglobin and vaporizes water, which leads to ablation. Laser is used for cutting and coagulating gingiva and mucosa and is therefore a soft tissue laser. Rather than displacing gingival tissue, diode lasers remove the epithelial lining from the sulcus. The superficial layers of 54 cells from the inner lining of the gingival sulcus should be removed to a depth just below the finishing line of the preparation. Hemostasis eliminates any seepage of fluid and blood in the sulcus and, therefore, enhances the quality of the final impression. Diode lasers cause minimal collateral tissue damage when used at the correct power. Removing the superficial layers of the sulcular epithelium without damaging the basal cell layer and connective tissue cells prevent shrinkage of the gingival tissue. The gingival sulcus is lined by sulcular epithelium with two basal layers of cells, from which remaining cell layers proliferate. If retraction procedure is carried out by removing superficial layers of epithelium, without damaging basal cell layer and connective tissue cells, the tissue changes and shrinkage of gingiva can be avoided22. The applications of lasers in gingival retraction were made possible with the use of flexible optical fibres ensuring high precision of laser action at the cervicular sulcus level.in this study, the advantage of using lasers was that it was a faster procedure, it stopped bleeding effectively and thus had a less aggressive effect on the periodontal tissues along with patient comfort. As compared to conventional techniques, laser offers certain advantages such as lesser operating times and lesser collateral heat generation, with good hemostasis and patient comfort. But it does not offer much of tactile feedback to the operator during the procedure. Use of diode lasers for retraction purposes has shown less recession around natural teeth as compared to retraction cord (2.2 percent versus 10.0 percent) with laser. Retraction studies have shown bacterial reduction at treatment site and improvement in gingival marginal health after 1 week. The main disadvantage with laser was that local anaesthesia was a must and a smaller cervicular retraction was recorded. The use of the laser unit with lower power can cause a dragging cutting action, which shreds the tissue. A higher power provides a better and smoother trough around the preparation. However, excessive power, which results in necrosis of the tissue, should be avoided. Enrico et al evaluated tissue retraction and gingival bleeding after performing gingival retraction

with soft tissue diode lasers, Nd:Yag laser, double cord technique and electrosurgery31

There is no consensus cited in the literature regarding criteria for evaluation of the clinical efficiency with gingival retraction cords. The only criteria for assessment of clinical performance of retraction cords identified in dental literature is the ability to stop bleeding and indirect assessments of the sulcus dilation with impression materials and assessing the section of dies by travelling microscope. Direct intra oral measurement with a modified Boley's gauge with a miniature video camera, periodontal probes and flexible scales were also reported. The use of flexible scales also can produce errors during visualisation of the markings intraorally. low power microscope to measure on the cast of prepared abutment, specifically designed dental endoscopic images, ultra sonographic periodontal probe, centrally rotating periodontal probe and remote-recording periodontal depth probe, manual periodontal probe,flexible strip, stereomicroscopic images of the impression and digital vernier calipers are a few of the other methods mentioned in the literature32

The application of computer-aided design/computer-aided manufacturing (CAD/CAM) restorations provides innovative, state-of-the-art dental service, and its application has increased significantly in the last years21 Conventional high precision impression materials, like hydrocolloid, polyether, polyvinyl or polysulfide in combination with stone casts, offer a well-known procedure to transfer the clinical situation into the laboratory . Several drawbacks are present in relation to conventional impressions. The potential distortion of the impression due to limited suitability for storage, deficient dimensional stability, disinfection in antiseptic solution, partial or extensive separation of the impression material from the tray, transport into the dental laboratory at different climatic conditions and the overall long process chain has to be mentioned. Additionally, the choice of the impression technique seems to influence the accuracy of dental impressions, hence the fitting of the resulting restorations. Besides, discomfort for the patient like sweating, gagging, pain and partially inconvenient taste is a known issue associated with conventional impression taking. In several situations, this instability and discomfort factor might be avoided by direct data capturing, which represents a logical direct access to dental CAD/CAM. With this technique, the intraoral surfaces are captured directly in the patient's mouthusing optical technologies. Thus digital impressions were used to measure the amount of gingival retraction using three shape software. The software allows two precise points to be marked between the finish line and the gingiva and distance can be measured on the scanned image.

Conclusion

Within the limitations of the study, it can be concluded that

1. The mean amount of lateral gingival retraction performed with merocel strips is 0.84mm, 0.84mm, 0.79mm and 0.78mm in the midfacial, mesial, distal and palatal regions.
2. The mean amount of lateral gingival retraction performed with soft tissue diode lasers is 0.71mm, 0.70mm, 0.68mm and 0.71mm in the midfacial, mesial, distal and palatal regions
3. The lateral gingival retraction achieved by merocel was greater than soft tissue diode lasers when assessed using intra oral digital scanners.

Legend Figure

Fig 1: Armamentarium required

Fig 2: Soft tissue diode laser

Fig 3. Pre treatment photographs

Fig 4:Tooth preparation wrt 25

Fig 5: Gingival retraction performed with merocel wrt 25

Fig 6: Gingival retraction performed with soft tissue diode laser

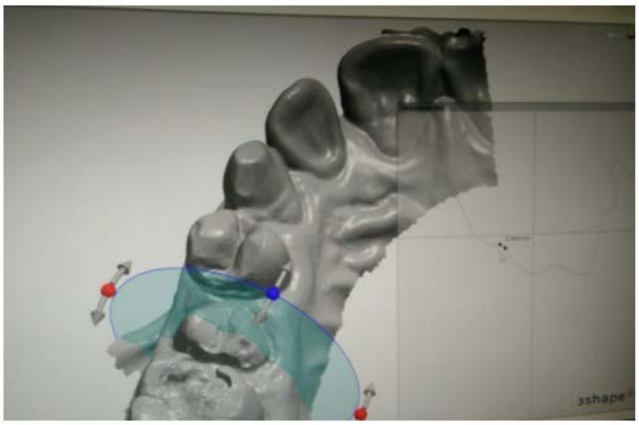


Fig 7: 3 shape software

References

1. Harrison JD. Effect of retraction materials on the gingival sulcus epithelium. Journal of prosthetic Dentistry. 1961 May 1;11(3):514-21.
2. Azzi R, Tsao TF, Carranza Jr FA, Kenney EB. Comparative study of gingival retraction methods. The Journal of Prosthetic Dentistry. 1983 Oct 1;50(4):561-5.
3. Weir DJ, Williams BH. Clinical effectiveness of mechanical-chemical tissue displacement methods. Journal of Prosthetic Dentistry. 1984 Mar 1;51(3):326-9
4. Abdel GF, Aboulazm SF. Comparative study on gingival retraction using mechanochemical procedure and pulsed Nd= YAG laser irradiation. Egyptian dental journal. 1995 Jan;41(1):1001.
5. Passes H, Furman M, Rosenfeld D, Jurim A. A case study of lasers in cosmetic dentistry. Current opinion in cosmetic dentistry. 1995:92-9.
6. Ferrari M, Cagidiaco MC, Ercoli C. Tissue management with a new gingival retraction material: a preliminary clinical report. Journal of Prosthetic Dentistry. 1996 Mar1;75(3):242-7.
7. Chen YJ, Jeng JH, Lee BS, Chang HF, Chen KC, Lan WH. Effects of Nd: YAG laser irradiation on cultured human gingival fibroblasts. Lasers in Surgery and Medicine: The Official Journal of the American Society for Laser Medicine and Surgery. 2000;27(5):471-8.
8. Donovan TE, Chee WW. Current concepts in gingival displacement. Dental Clinics of North America. 2004 Apr;48(2):vi-433.
9. Liu CM, Huang FM, Yang LC, Chou LS, Chou MY, Chang YC. Cytotoxic effects of gingival retraction cords on human gingival fibroblasts in vitro. Journal of Oral Rehabilitation. 2004 Apr;31(4):368-72.
10. Gherlone EF, Maiorana C, Grassi RF, Ciancaglini R, Cattoni F. The Use of 980-nm Diode and 1064-nm Nd: YAG Laser for Gingival Retraction in Fixed Prostheses. Journal of Oral Laser Applications. 2004 Jun 1;4(3).
11. Parker S. The use of lasers in fixed prosthodontics. Dental Clinics of North America. 2004 Oct 1;48(4):971-8.
12. Scott A. Use of an erbium laser in lieu of retraction cord: a modern technique. Gen Dent. 2005 Mar;53(2):116-9.
13. Polat NT, Özdemir AK, Turgut M. Effects of Gingival Retraction Materials on Gingival Blood Flow. International journal of prosthodontics. 2007 Jan 1;20(1).
14. Wöstmann B, Rehmann P, Balkenhol M. Influence of Different Retraction Techniques on Crevicular Fluid Flow. International Journal of Prosthodontics. 2008 May 1;21(3).
15. Wöstmann B, Rehmann P, Trost D, Balkenhol M. Effect of different retraction and impression techniques on the marginal fit of crowns. Journal of dentistry. 2008 Jul 1;36(7):508-12.
16. Al Hamad KQ, Azar WZ, Alwaeli HA, Said KN. A clinical study on the effects of cordless and conventional retraction techniques on the gingival and

periodontal health. Journal of clinical periodontology. 2008 Dec;35(12):1053-8.

17. Phatale S, Marawar PP, Byakod G, Lagdive SB, Kalburge JV. Effect of retraction materials on gingival health: A histopathological study. Journal of Indian Society of Periodontology. 2010 Jan;14(1):35.
18. Syrek A, Reich G, Ranftl D, Klein C, Cerny B, Brodesser J. Clinical evaluation of all-ceramic crowns fabricated from intraoral digital impressions based on the principle of active wavefront sampling. Journal of dentistry. 2010 Jul 1;38(7):553-9.
19. Lee SJ, Gallucci GO. Digital vs. conventional implant impressions: efficiency outcomes. Clinical oral implants research. 2013 Jan;24(1):111-5.
20. Gupta A, Prithviraj DR, Gupta D, Shruti DP. Clinical evaluation of three new gingival retraction systems: A research report. The Journal of Indian Prosthodontic Society. 2013 Mar 1;13(1):36-42.
21. Güth JF, Keul C, Stimmelmayr M, Beuer F, Edelhoff D. Accuracy of digital models obtained by direct and indirect data capturing. Clinical oral investigations. 2013 May 1;17(4):1201-8.
22. Ch VK, Gupta N, Reddy KM, Sekhar NC, Aditya V, Reddy GM. Laser gingival retraction: a quantitative assessment. Journal of clinical and diagnostic research: JCDR. 2013 Aug;7(8):1787.
23. Seelbach P, Brueckel C, Wöstmann B. Accuracy of digital and conventional impression techniques and workflow. Clinical oral investigations. 2013 Sep 1;17(7):1759-64.
24. Anupam P, Namratha N, Vibha S, Anandakrishna GN, Shally K, Singh A. Efficacy of two gingival retraction systems on lateral gingival displacement: A prospective clinical study. J Oral Biol Craniofac Res. 2013;3(2):68-72. doi:10.1016/j.jobcr.2013.05.006
25. Wismeijer D, Mans R, van Genuchten M, Reijers HA. Patients' preferences when comparing analogue implant impressions using a polyether impression material versus digital impressions (Intraoral Scan) of dental implants. Clinical oral implants research. 2014 Oct;25(10):1113-8.
26. Wismeijer D, Mans R, van Genuchten M, Reijers HA. Patients' preferences when comparing analogue implant impressions using an polyether impression material versus digital impressions (Intraoral Scan) of dental implants. Clinical oral implants research. 2014 Oct;25(10):1113-8.
27. Yuzbasioglu E, Kurt H, Turunc R, Bilir H. Comparison of digital and conventional impression techniques: evaluation of patients' perception, treatment comfort, effectiveness and clinical outcomes. BMC oral health. 2014 Dec;14(1):10.
28. Lee SJ, Betensky RA, Gianneschi GE, Gallucci GO. Accuracy of digital versus conventional implant impressions. Clinical Oral Implants Research. 2015 Jun;26(6):715-9.
29. Ender A, Attin T, Mehl A. In vivo precision of conventional and digital methods of obtaining complete-arch dental impressions. The Journal of prosthetic dentistry. 2016 Mar 1;115(3):313-20.
30. Papaspyridakos P, Gallucci GO, Chen CJ, Hanssen S, Naert I, Vandenberghe B. Digital versus conventional implant impressions for edentulous patients: accuracy outcomes. Clinical oral implants research. 2016 Apr;27(4):465-72.
31. Stuffken M, Vahidi F. Preimpression troughing with the diode laser: A preliminary study. The Journal of Prosthetic Dentistry. 2016 Apr 1;115(4):441-6.
32. Chochlidakis KM, Papaspyridakos P, Geminiani A, Chen CJ, Feng IJ, Ercoli C. Digital versus conventional impressions for fixed prosthodontics: A

systematic review and meta-analysis. The Journal of prosthetic dentistry. 2016 Aug 1;116(2):184-90.

33. Rajambigai MA, Raja SR, Soundar SJ, Kandasamy M. Quick, painless, and atraumatic gingival retraction: An overview of advanced materials. Journal of pharmacy & bioallied sciences. 2016 Oct;8(Suppl 1):S5.
34. Rashid R. Comparative study on the efficacy of gingival retraction using polyvinyl acetate strips and conventional retraction cord.
35. Ahlholm P, Sipilä K, Vallittu P, Jakonen M, Kotiranta U. Digital versus conventional impressions in fixed prosthodontics: a review. Journal of Prosthodontics. 2018 Jan;27(1):35-41.
36. Thimmappa M, Bhatia M, Somani P, Kumar DR. Comparative evaluation of three noninvasive gingival displacement systems: An in vivo study. The Journal of Indian Prosthodontic Society. 2018 Apr 1;18(2):122.
37. Melilli D, Mauceri R, Albanese A, Matranga D, Pizzo G. Gingival displacement using diode laser or retraction cords: A comparative clinical study. American journal of dentistry. 2018 Jun;31(3):131-4.
38. Tao X, Yao JW, Wang HL, Huang C. Comparison of Gingival Troughing by Laser and Retraction Cord. International Journal of Periodontics & Restorative Dentistry. 2018 Jul 1;38(4).
39. Indriyani A, Masulili C, Odang RW. Effect of Gingival Retraction Method to Lateral Gingival Displacement Width. Pesquisa Brasileira em Odontopediatria e Clínica Integrada. 2019;19.
40. Dederichs M, Fahmy MD, Kuepper H, Guentsch A. Comparison of Gingival Retraction Materials Using a New Gingival Sulcus Model. JProsthodont. 2019;28(7):784-789. doi:10.1111/jopr.13093