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Clinical Applications of Laser in Complete And Partial Removable Prosthodontics- A Literature Review

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ABSTRACT-

The success of any prosthesis depends on how well the surrounding tissues respond and accept it. For complete denture prostheses, combining prototyping and CAD/CAM technology with laser technology has proven effective. Rapid prototyping creates physical replicas from CAD data, functioning like a 3D copier, allowing for precise prosthesis fitting. CAD/CAM and laser technologies are used to create metallic denture bases layer by layer. In severe cases, pre-prosthetic surgery may be recommended to enhance prosthesis performance. Lasers are effective in treating resorbed ridges, hyperplastic tissues, and other

conditions, especially in managing alveolar ridge resorption, which progresses with age and is more rapid in women. Alveolar ridge resorption is influenced by systemic, hormonal factors, and oral hygiene habits, leading to bone shrinkage and flattened ridge platforms.

INTRODUCTION-

As is widely recognized, the ultimate success of any prosthesis hinges largely on the response and acceptance of the surrounding soft and hard tissues. In the realm of complete denture prostheses, the integration of prototyping and computer-aided design/manufacturing (CAD/CAM) technology is often coupled with laser technology. Rapid prototyping, in essence, involves the automated generation of physical replicas based on data and specifications derived from computer-aided design. Consequently, rapid prototyping functions akin to a three-dimensional copier, empowering clinicians to craft precisely fitting prostheses that meet clinical standards. Primarily, the metallic denture base is fashioned using CAD/CAM technology in conjunction with laser technology. Essential components include laser scanners, standardized software, and replicated denture foundations containing encoded data. This innovative approach to fabrication employs a layering technique, wherein the denture base is constructed incrementally, layer by layer.[1]

In certain extreme cases, patients may be recommended to undergo pre-prosthetic surgery to optimize the performance and acceptance of their prostheses. Numerous studies have demonstrated the successful use of lasers in clinically managing highly resorbed ridges, hyperplastic tissues, and other abnormalities or trauma-related conditions. Treating inadequate alveolar ridges is a critical application of lasers in Prosthodontics. Alveolar ridge resorption, often influenced by systemic and hormonal factors as well as the deterioration of the tooth-supporting system, typically occurs with advancing age and is usually irreversible. Women tend to experience alveolar ridge resorption at a faster rate than men. Normally, alveolar ridge resorption involves the simultaneous vertical and lateral shrinking of bone, resulting in a flattened ridge platform. Additionally, the history of a patient's oral hygiene habits can influence alveolar ridge resorption.[1]

Alveoloplasty-

In complete dentures, laser technology can successfully manage the clinical undercutting of alveolar ridges. Many researchers suggest that minor bony undercuts can be disregarded, contributing to denture stability. However, severe or bilateral undercuts may necessitate surgical intervention, particularly prevalent in the maxillary anterior region. Therefore, it is essential to surgically manage these undercuts before initiating prosthodontic therapy. Typically, laser-based management utilizes Erbium lasers, while CO2, diode, and Nd: YAG lasers are employed for related soft tissue treatments.[1]

Frenectomy and Vestibuloplasty-

There are indications for surgical removal of labial or lingual frenum, especially for pre-prosthetic, orthodontic and phonetic reasons. Vestibuloplasties serve as pre-prosthetic surgical procedures for improvement of denture retention. Denture stability and wearing comfort are improved by the relative increase of the height of the alveolar ridge. In comparison to conventional methods, surgical interventions with the CO2, Nd: YAG, or diode lasers are associated with low intra- and postoperative complications and good wound healing.[2]

Frenectomy-

Labial or lateral frenum is indicated very often for surgical excision, when muscular attachments can negatively affect the periodontal condition of the adjacent teeth, speech, and also esthetics, especially in patients with a high smile line.

There is common agreement between clinicians that frenectomy should be performed after complete eruption of the permanent canines, which determine the final position of the six anterior teeth and therefore may close the midline diastema.

The laser frenectomy can be performed with almost all different laser wavelengths. The clinician is advised to read carefully the laser-tissue interactions since tissue color and used laser wavelength determine power settings and certainly penetration within the tissue. This is significant in order to provide a clinical outcome without complications.

An average power between 4–6W is sufficient for frenectomies of the lip or lingual frenum with the CO2 laser. Using the Nd: YAG laser, a power of 4W should not be exceeded in order to avoid pain and postoperative scar tissue formation. The incision design in a V-shape allows removing the muscular attachment over the periosteum creating a new established vestibule. Suturing is usually not necessary. The final tissue ablation in the entire surgical field allows a wound dressing, protecting the tissue from infections, as well as relief of postsurgical pain.[2]

Excision of the labial frenum (a) using a focused 810 nm diode laser with initiated fiber, in contact with the tissue during excision. The average power was 2 W (CW) providing sufficient bleeding control (b). A fibrin layer covered the wound four days after surgery (c) and showed a complete healing two weeks after surgery (d). *Source:* Dr. Georgios E Romanos.

Vestibuloplasty-

Vestibuloplasties are surgical procedures aimed at improving the depth of the vestibule in the maxilla and/or mandible, serving as pre-prosthetic interventions. These procedures enhance the retention of partial or full dentures by facilitating better adaptation of the denture flange to the alveolar ridge following the dissection of the muscular attachment. Since the procedure increases the height of the alveolar ridge, it is considered a "relative augmentation."

Use of CO2 Laser-

Advantages:

- Superior incision quality.
- Shorter surgical time.

Procedure:

- The muscular attachment is excised over the periosteum to achieve optimal vestibule depth, thereby enhancing the mechanical retention of the prosthesis.
- Dental CO2 lasers typically operate at a maximum power of 10W in continuous mode, though high power settings are unnecessary.
- Incisions are made using a noncontact handpiece.

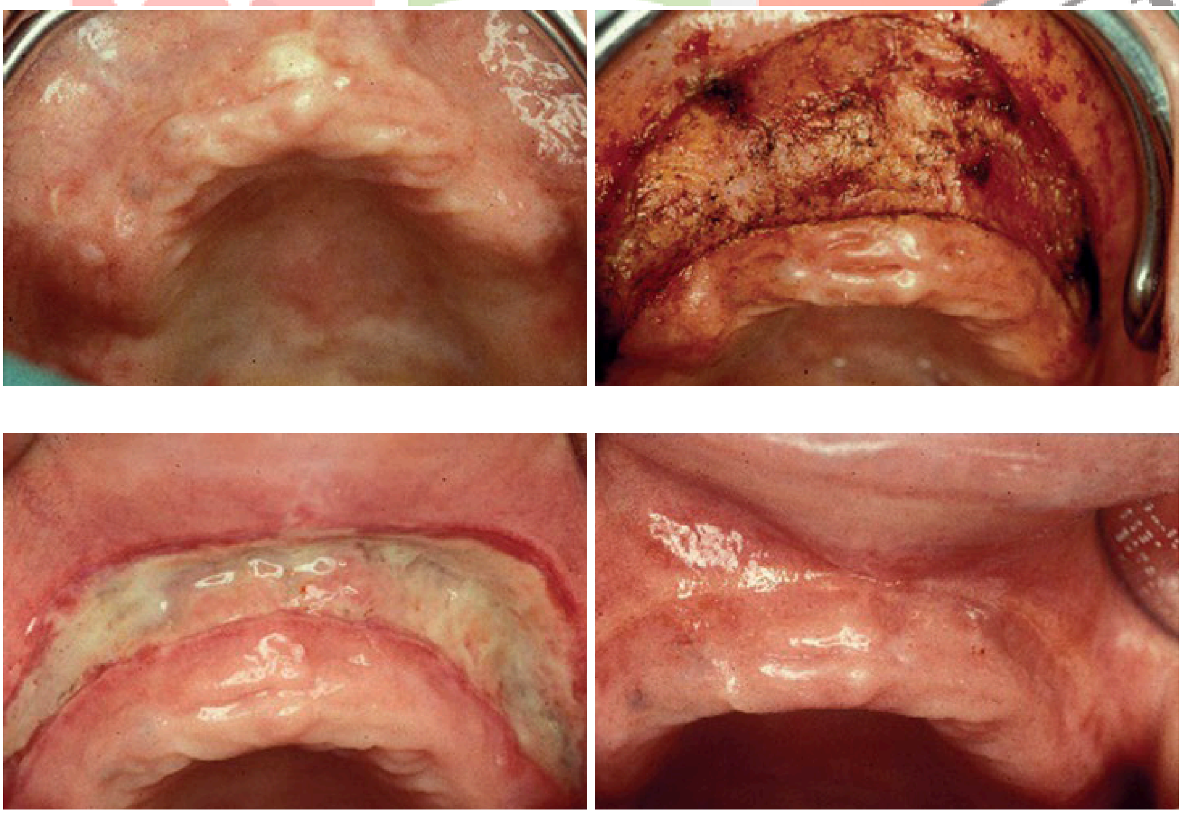
- Charring the surgical area with a defocused beam ensures good hemostasis and serves as a wound dressing.

Comparative Laser Options:

- Diode Lasers:
- Offer better hemostasis compared to CO_2 lasers.
- Nd: YAG Laser:
- Provide excellent coagulation but have a higher risk of scar tissue formation and require a longer operation period.

Post-Surgical Care-

- The periosteum remains intact, and the mobile mucosa is immobilized with sutures at the deepest point of the vestibular fold.
- The denture flanges are extended and relined to compress the underlying tissues, acting as a surgical stent for 7 to 10 days.
- No special post-surgical measures are typically needed beyond routine oral hygiene.
- Four weeks post-surgery, no pathological conditions are usually observed, and postsurgical bleeding or swelling are uncommon.[5]



Lack of vestibule depth before surgery
(a)The incision was performed with a noncontact handpiece of a CO2 laser (average power: 6-10 W, CW), separating the underlying attached muscle fibers from the periosteum with simultaneous coagulation of the blood vessels
(b)Fibrin layer covered the wound surface seven days after surgery
(c)At the three month-follow up, the tissue was free of scar or muscular reattachment (recurrence), and an increased vestibule depth allowed the retention of the full denture
(d)*Source:* Dr. Georgios E Romanos.

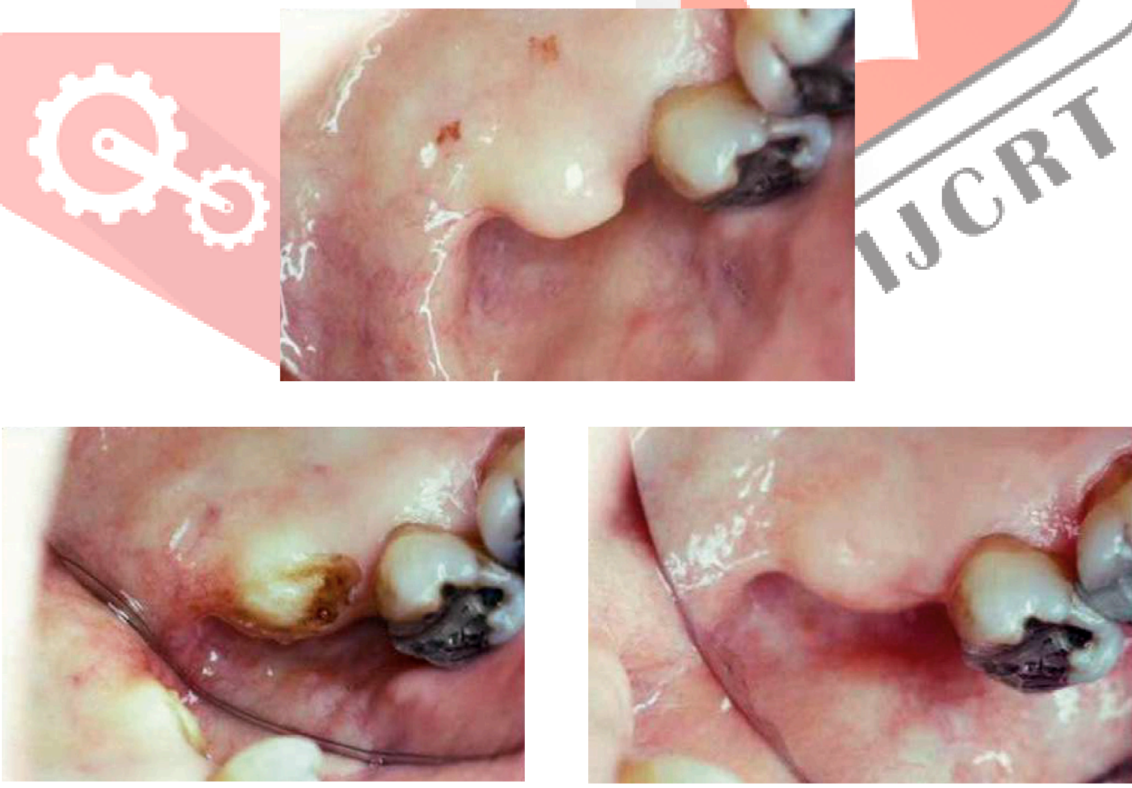
Excision of Epulis Fissuratum-

The conventional methods for correcting epulis often face challenges such as extensive contracture of the vestibule, leading to compromised denture fit. However, the use of lasers, particularly carbon dioxide (CO2) lasers, has emerged as a significant advancement in the management of epulis fissurata. Studies, such as the one conducted by Keng and Loh, have demonstrated the effectiveness of CO2 lasers in removing epulies with minimal complications and excellent long-term outcomes. Laser surgery offers advantages such as lack of wound contraction and relapse, reduced postoperative complications, and improved patient perception compared to conventional techniques. Moreover, laser treatment of epulis has shown promising results in terms of relapse rates and patient comfort during procedures. The absence of contraindications to laser treatment further supports its use as a safe and effective approach for managing epulis. Therefore, the adoption of CO2 lasers represents a valuable addition to the armamentarium of dental practitioners, offering patients improved outcomes and a more favorable treatment experience.[2]

Tuberosity Reduction

In the process of treatment planning for full or partial upper dentures, careful consideration of the maxillary tuberosity is crucial due to its potential impact on prosthesis fit and stability. While some tuberosities may be inconsequential, others may present challenges such as being large, flabby, or possessing bilateral undercuts that hinder proper prosthesis fabrication. To assess the tuberosity accurately, a radiographic series is necessary to determine tissue composition, as palpation alone may not suffice. Treatment approaches vary depending on the nature of the tuberosity: hypertrophied soft tissue may require reduction through surgical means, while osseous tissue may necessitate a hard tissue reduction procedure. Additionally, in cases where a pneumatized sinus is present, a sinus lift procedure may be warranted. Soft tissue tuberosity reductions aim to provide adequate maxilla-mandibular clearance for denture placement, typically requiring a minimum of 5 mm of clearance between the tuberosity and mandibular mucosa. Procedures for soft tissue reduction involve elliptical incisions, tissue removal, and primary closure, while osseous tissue reductions involve reflection of the mucoperiosteum, bone removal, and careful closure to avoid complications. It's important to note potential risks, such as avoiding damage to the greater palatine artery and its branches during conventional techniques, as emphasized by Guernsey. Thus, thorough evaluation and precise execution are essential for successful management of the maxillary tuberosity during prosthodontic treatment planning.[2]

Laser tuberosity reduction presents several advantages over traditional techniques, as highlighted by Pick. Conventional methods often encounter challenges during tissue thinning and trimming, leading to potential complications such as inadequate flap size for primary closure and difficulty in suturing. However, laser-assisted tuberosity reduction eliminates the need for incisions and sutures. The laser vaporizes soft tissue layer by layer, achieving the desired maxilla-mandibular space without the need for surgical incisions. This approach is applicable to patients wearing full dentures or those planning to receive dentures, as demonstrated by Convissar and Gharemani's case study. Laser-assisted procedures offer accelerated healing and reduced trauma, shortening treatment periods significantly. Furthermore, the absence of incisions and sutures leads to quick and uneventful healing, minimizing the risk of complications such as accidental sinus perforation. Additionally, the cauterizing effect of lasers reduces the risk of inadvertently severing blood vessels, such as the palatine artery, further enhancing safety. Pogrel's study further supports the efficacy of laser tuberosity reduction, demonstrating faster healing, reduced discomfort, and shorter treatment times compared to conventional methods. Consequently, the advantages of laser technology make it a valuable tool for soft tissue pre-prosthetic surgery, offering improved patient comfort and outcomes.[2]



Tuberosity reduction.

A Preoperative photograph of enlarged soft tissue tuberosity.

B Tuberosity reduction performed using a simple ablation technique, with no incision or sutures.

C Postoperative view of surgical site at 17 days. Note excellent healing and Re-epithelialization of surgical site. Excellent contours of site have been achieved without incisions or sutures.

Soft Tissue Tuberosity:

The process for conducting a soft tissue laser tuberosity reduction is relatively straightforward. First, diagnostic radiographs are obtained to determine the sinus floor's location and mounted study casts to assess the required surgical reduction. Local anesthesia is administered both buccally and palatally. Then, using a large spot size/fiber or handpiece, the selected laser is employed at a surgical setting to ablate the tuberosity tissue layer by layer until the desired maxilla-mandibular space is achieved. It's crucial to keep the laser tip as parallel as possible to the tuberosity for maximum efficiency. Subsequently, the laser beam is moved out of focus to ensure adequate hemostasis, and any irregularities or tissue tags are ablated. Finally, the denture may be relined with a tissue conditioner or soft reline material, and the patient is provided with postoperative instructions, emphasizing maintaining a clean surgical site and oral hygiene, followed by scheduling a follow-up appointment.[2]

Hard Tissue Tuberosity:

Various options are available for hard tissue laser tuberosity reduction, depending on the available wavelengths. If only a soft tissue wavelength is accessible (such as CO2, diode, or Nd:YAG), an elliptical incision is made into the tuberosity to expose the osseous structure, followed by reduction using the clinician's preferred instrument, such as a Rongeur or a round bur with copious water spray. The advantages of using a laser over a scalpel, including superior hemostasis and dry surgical sites, are evident in this technique. The surgical site is then closed with sutures. Alternatively, if a hard tissue laser is available (such as Er:YAG, Er,Cr:YSGG, or possibly the 9300-nm CO2 laser), the soft tissue incision is made with the laser, followed by slow and methodical ablation of the bone using the hard tissue laser. It's important to note that shutting off the water spray when incising the soft tissue and using a copious water spray on the bone during bone removal ensures maximum spallation and cutting efficiency with minimal thermal damage to the bone.[2]

Removal of Tori-

Mandibular tori, found in about 8% of the population, may require reduction if they interfere with denture fabrication. Laser torus reduction, akin to hard tissue tuberosity reduction, involves making an incision to expose the bone, reducing the bone, and suturing the incision. While surgical risks exist, complications are potentially more severe when operating near the floor of the mouth, with reports of hematoma formation and life-threatening swelling. Notably, laser-assisted procedures have shown fewer complications, likely due to superior hemostasis and reduced tissue manipulation. Payas described a combined CO2 and erbium laser approach for lingual torus reduction, with uneventful healing. The choice of technique varies among practitioners, with some favoring hard tissue lasers for torus and tuberosity reductions. Similarly, palatal tori, occurring more frequently in females, may necessitate reduction before prosthesis fabrication, with potential complications including nasal perforation and palatal fractures. For palatal torus reduction, careful bone ablation using lasers, particularly erbium lasers, is advocated for safety, with the option to use palatal stents to prevent hematoma formation. Ultimately, the clinician must weigh the benefits and limitations of available laser wavelengths to ensure safe and effective treatment.[2]

Removal of Papillary Hyperplasia-

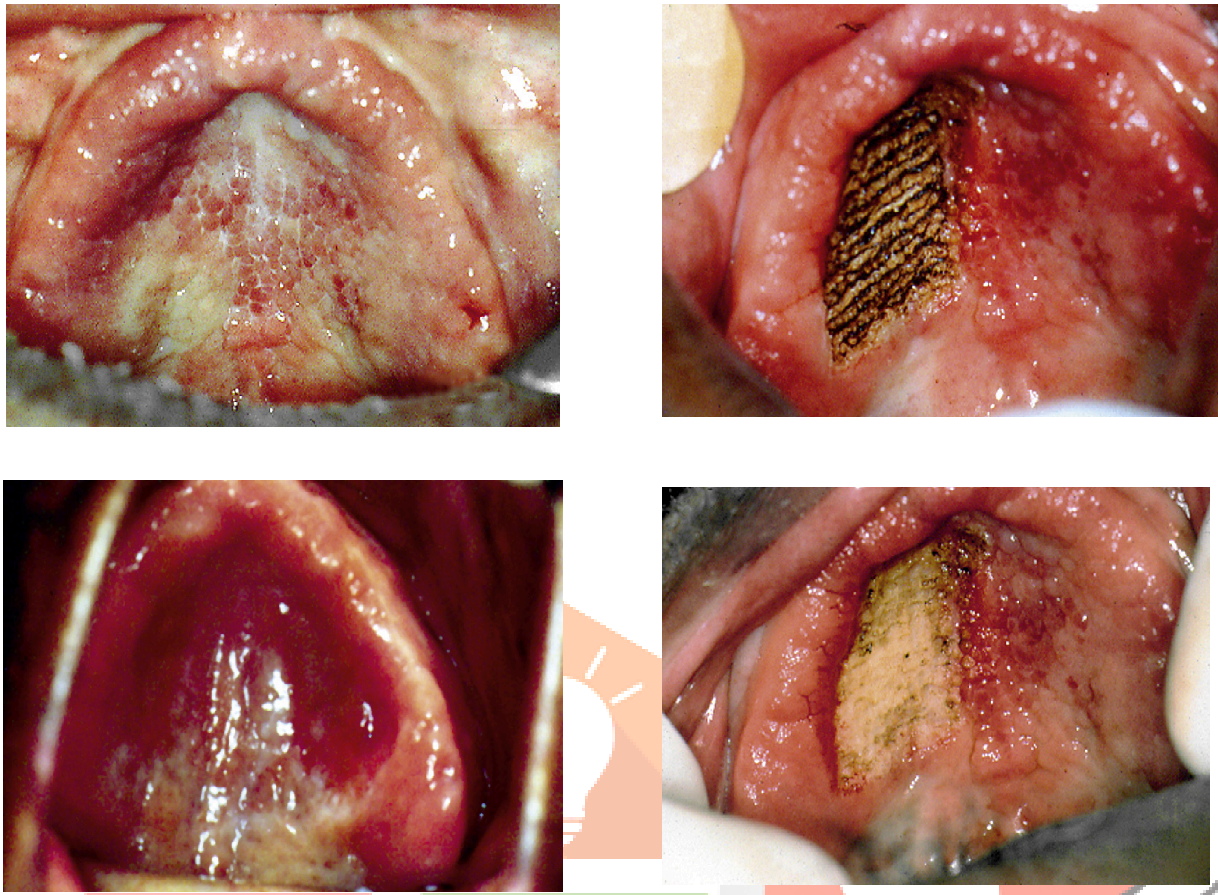
The utilization of lasers in treating papillary hyperplasia has been extensively documented in the literature. According to Terry and Hillenbrand, conventional treatments often result in complications such as hemorrhage, whereas laser treatment offers significant advantages in preventing bleeding through coagulation and cauterization of the site. In a study by Pogrel involving 11 patients, laser treatment showed no instances of bleeding, swelling, or nerve damage. CO2 lasers, in particular, offer various benefits for treating papillary hyperplasia, including ease of navigating tissue curves, minimal bleeding, a dry surgical field, speed, and minimal postoperative pain and swelling. Moreover, they exhibit superb effectiveness in vaporizing the affected tissue without the need for incision or excision procedures.[2]

Papillary hyperplasia, being a superficial mucosal lesion, is ideally treated with laser energy directed through a large fiber/spot size or handpiece in a defocused mode. This approach covers the entire lesion with laser energy, facilitating superficial vaporization of the affected tissue without the need for incisions. Infante Cossio et al. described a case where topical antifungal gel treatment failed to heal the lesion, whereas CO2 laser vaporization successfully resolved the condition with no recurrence even after 3 years.[2]

The effectiveness of laser treatment for papillary hyperplasia is illustrated, depicting a severe case where a CO2 laser in defocused mode was used to vaporize the lesion. Removal of the char layer revealed complete elimination of the lesion, demonstrating the efficacy of laser therapy in managing papillary hyperplasia.

Other oral mucosal lesions commonly associated with the use of removable prosthetic devices include denture stomatitis, traumatic ulcers, and angular cheilitis. Denture stomatitis affects up to 50% of patients wearing partial or full dentures, while traumatic ulcers occur in about 5% of denture wearers, and angular cheilitis affects approximately 15% of patients with full dentures. Laser treatment using defocused energy is effective for managing these lesions, and low-level laser therapy (LLLT) is also a viable option.

In a study by Marei et al., 18 patients were divided into three groups based on the treatment modality: denture removal for a specified period, denture relining with tissue-conditioning material, and low-level laser irradiation. The results demonstrated superior healing in the LLLT group compared to the other two groups.[2]



Severe papillary hyperplasia.

A, Preoperative view.

B, Horizontal defocused ablation of right side of palate. Because this is a vaporization/ablation procedure rather than an incision/excision procedure, the laser is used slightly out of focus.

C, Wet gauze used to remove char layer, which was expected using older-model CO_2 laser unit. The newer superpulsed or ultraspeed CO_2 lasers no longer create char layers on tissue because their high peak powers are delivered in a much shorter burst, or pulse, of energy.

D, Postoperative view at 2 weeks shows good initial healing.

Investigating the accuracy of impression and complete denture occlusion-

In investigating the accuracy of impression and complete denture occlusion, a newly developed laser scanner serves as a 3D digitizer, tracking the specimen's coordinates (x, y, and z) with a resolution of 130 mm at 100 mm. This scanner captures complex 3D texture-mapped models, which are then transferred to a 3D software tool (Scan Surf). In this software, the models are constructed and triangulated into a 3D meshwork image of the object.[3]

Utilizing a 3D model is preferred over a 2D model for its comprehensive representation. The laser scanner, functioning as a 3D digitizer, does not require direct contact with the objects, ensuring precise data recording and storage. The 3D digitizer is seamlessly integrated with the software and the design image, facilitating the fabrication of an accurate prosthesis.

Landmarks on the 3D models serve as guides for fabrication, streamlining the tracking process and enabling the creation of standardized prostheses.[3]

Laser welding of a cobalt-chromium removable partial denture alloy-

In dentistry, two primary methods are commonly employed to join metal parts, particularly cobalt-chromium (Co-Cr) alloy: soldering and brazing. Soldering refers to joining below 425°C, while brazing involves temperatures above 425°C. Both techniques utilize a medium, typically gold or silver solder, with a lower melting point than the parent metal, along with a heat source such as a gas torch or electric soldering unit.[4]

However, traditional soldering and brazing methods have drawbacks, including low tensile strength, the creation of a heat-affected zone (HAZ) that alters the parent alloy's grain size, and potential damage to adjacent materials with lower melting points. To address these limitations, researchers have explored alternative heat sources such as infrared and laser technology.[4]

In recent years, laser welding has emerged as a promising fusion welding technique, particularly for dissimilar metals. Modern lasers offer precise focal points and can impart energy into metal efficiently. Laser welding involves focusing a single frequency light beam to create a localized temperature above the liquid, causing the metal to evaporate and form a cavity or keyhole. Molten metal from a reservoir around the keyhole fills the hole as the heat source moves forward, forming the weld bead.[4]

Laser welding has gained popularity in various industries due to its ability to produce strong joints with minimal distortion of the workpiece. Although laser welding has been extensively studied for joining materials like commercially pure titanium and titanium alloy in dentistry, there is a lack of research on its application for partial denture alloys.

Overall, laser welding shows promise for overcoming the limitations of traditional soldering and brazing techniques in dentistry, offering potential benefits such as improved joint strength, reduced distortion, and a narrower heat-affected zone. Further research is needed to explore its feasibility and efficacy for joining partial denture alloys.

The results of the study comparing laser fusion welding and electric brazing for joining cobalt-chromium (Co-Cr) removable partial denture alloy surfaces revealed several significant findings. Laser fusion welding demonstrated higher tensile strength compared to electric brazing, which can be attributed to the characteristics of each joining technique.[4]

In electric brazing, the electrode tip generates temperatures below the melting point of the parent metal, allowing the filler material to bond to the parent metal surface without fusion. However, the bonding between the soldering material and the parent metal is adhesive, resulting in lower tensile strength due to porosity and mechanical defects within the joint. Laser welding, on the other hand, forms joints in a controlled gas chamber, eliminating atmospheric contact and producing stronger bonds.[4]

However, the study also indicated that Nd:YAG laser welding influenced the properties of the Co-Cr alloy, resulting in microstructural changes in the heat-affected zone (HAZ). These changes, including grain growth and residual stress, may lead to decreased tensile strength and embrittlement in the joint. To mitigate these effects, further experiments are needed to explore the advantages of using full penetration welding techniques with a single pass to minimize the number of HAZs.[4]

Nd:YAG laser welding offers several advantages in removable prosthodontics, including the ability to join Co-Cr surfaces with improved physical properties and joint toughness, reducing the risk of joint failure from fatigue. Successful laser welding relies on a combination of factors such as beam power, welding speed, shielding gas, and operator skill. However, achieving full contact between the joining surfaces can be challenging in some cases, necessitating exploration of techniques using shims or filler wire of the same material.[4]

Overall, while laser fusion welding shows promise for enhancing the strength and durability of Co-Cr alloy joints in removable prosthodontics, further research and optimization of welding techniques are necessary to maximize its effectiveness and reliability.[4]

CONCLUSION-

The integration of laser technology in the management of removable dentures significantly enhances pre-prosthetic preparation, maintenance, and the treatment of related oral conditions. By offering precision, effective hemostasis, reduced postoperative pain, and faster healing, lasers improve the overall fit, comfort, and health outcomes for denture wearers. Whether in surgical interventions such as Vestibuloplasty and frenectomy, or in managing conditions like denture stomatitis and soft tissue hyperplasia, lasers provide a versatile and efficient solution, ensuring better patient satisfaction and quality of care.

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