RADIOSURGERY-ASSISTED GINGIVAL DISPLACEMENT: A PROOF OF CONCEPT TECHNIQUE TO ENHANCE THE EFFICIENCY OF INTRAORAL DIGITAL IMPRESSION

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Nowadays, an increasing number of dentists are using intraoral scanners (IOS) in their daily practice as an alternative to conventional impression taking. One of the main concerns is related to the capability of scanning the subgingival anatomy of the die, usually very challenging due to the limited operative field and the presence of oral fluids. The radiosurgery assisted gingival displacement technique (RAGD) may enhance the intraoral optical scanning of the finish line and neighbor tooth anatomy. The contour of the interim prosthesis is used to drive the tip of radiosurgery electrode along the tooth surface and open selectively the gingival crevice with a prosthetically-driven and minimally invasive approach. The clinical implication of this technique is related to increasing the efficiency and accuracy of the digital impression technique in the critical zone of the prosthetic shoulder.

Lack of margin precision and vertical and horizontal overhangs may cause periodontal tissues inflammation and may increase the risk of recurrent caries, especially for subgingivally-located crown margins (1, 2).

Although a supragingival margin is preferable to maintain a sound periodontal attachment (3), the patient can refuse such approach particularly in the area of the mouth of esthetic concern. Moreover, in certain clinical conditions the finish line needs to be placed subgingivally to increase the retention form, refine the preexisting margins, treat cervical caries or abrasion and cover the root surface to eliminate the sensitivity (2 ,4-6).

During the impression, taking the gingival displacement is necessary to record the finish line regardless of the conventional or digital methods used (6, 7). Besides, gingival fluid seepage and hemorrhage should be controlled to ensure acceptable impressions (8, 9). Several gingival displacement methods were described in the literature, classified as mechanic, mechano-chemical (chemicals embedded in cords or in an injectable matrix form), surgical (RS, electrosurgery (ES), lasers, and rotary curettage), or combinations of these (10, 11).

The precision of the IOS was reported to be clinically acceptable (12, 13) and their use seems easier for taking the impression of the implants than for natural teeth, because of the use of dedicated components (scan-bodies) detectable by the scanner regardless

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how much deep is the implant platform respect to the gingival margin (13-20).
The use of the IOS for taking the impression of the die and surrounded soft tissue architecture is limited by the operative access to the site. Opening of the gingival crevice is mandatory to ensure accurate recording of the finish line by means of the scanner light beam. The retraction cord may assist the clinician to displace the marginal gingiva, however later on, discerning the finish line from the cord itself in the software can be challenging (21). Moreover in case of retraction cords are associated with bleeding in more than 50 percent of situations (21). The need of a direct vision of the subgingival finish line as well as the absence of bleeding and cord artifacts requires a way for the clinician to clearly detect the emerging anatomy of subgingival dental preparations through IOS.
The RAGD technique is a proof of concept technique to enhance the digital impression of the prosthetic die, discerning the anatomy of the tooth from that of the gingival tissue at the finish line level. The RAGD technique uses the contour of the interim prosthesis to guide the tip of the radiosurgery electrode along the tooth surface to open the gingival crevice selectively with a prosthetically driven and minimally invasive approach.

Technique
Step 1: Fabricate an anatomically-contoured interim dental prosthesis.
Step 2: Prepare the tooth placing the finish line 1 mm subgingivally.
Step 3: Reline the interim prosthesis onto the die with an acrylic resin and refine chairside to deliver a well-polished surface and contour
Step 4: Let the soft tissues heal and mature for 3 weeks around the interim prosthesis contour (Fig. 1).
Step 5: Use a single-wire needle-type electrode with a monopolar cut mode RS [Surgitron® Dual RF; Ellman International, Inc (4.0 MHz frequency, fully rectified, filtered waveform)] with a 45 degrees angle, along the prosthetic contour all around the die except for the interproximal area adjacent to the contact surface, placing the tip of the electrode at the finish line level (Fig. 2).Step 6: Remove the interim fixed dental prosthesis and gently apply the tip of the electrode in the interproximal areas to open the gingival crevice underneath the contact surface.Step 7: Wait 5 min to control the bleeding and in case, use a hemostatic solution.
Step 8: Dry the interested area with an air syringe.
Step 9: Perform digital impression of the interested area through an IOS (Trios3; 3Shape A/S) (Fig. 3, 4).
Step 10: Wait three weeks for recovery of the soft tissues, before delivering the definitive cement-retained FDP (Fig. 5-8).

DISCUSSION

Detecting the subgingival dental preparations through an intraoral scanner is considered the weak part of the digital impression (13, 21). To the best of our knowledge, no techniques have been published to enhance the optical reading of the finish line of the subgingival preparations. The RAGD technique uses an anatomically-contoured provisional restoration to guide the radiosurgery electrode tip through the gingival crevice and displace the gingival margin horizontally.
Contraindications to its use are the presence of flammable anesthetics, liquids, or skin preparations and its use should be avoided in patients with severe periodontal disease and/or with metal restorations close to the interested area. Besides, when radio wave equipment is used in the presence of cardiac pacemakers or defibrillators, a cardiology consultation should be obtained (22).
Radio wave surgery causes tissue vaporization and potential smoke hazard from particulate inhalation. Precautions include careful and controlled smoke plume evacuation and wearing surgical masks rated for micro particle filtration. Although not a complication, inadequate removal of smoke will cause an unpleasant smell throughout the office (22).
The operator's experience and capability in the use of RS are relevant to the success of the technique. The comprehension of the device characteristics is fundamental to handle the high-frequency radiosurgery effectively and to limit the invasion of the periodontal tissues (22, 23). After the application of RAGD, it should wait 3 weeks for the soft tissues

Fig. 1. *Interim prosthesis temporarily cemented.*

Fig. 2. *RAGD Technique applied on the buccal side.*

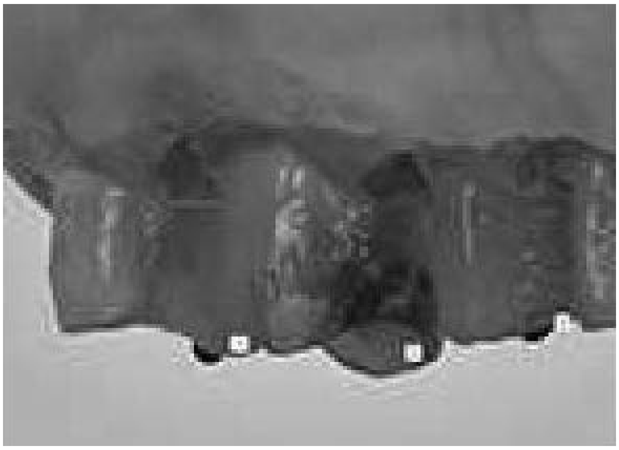

Fig. 3. *Digital impression buccal view.*

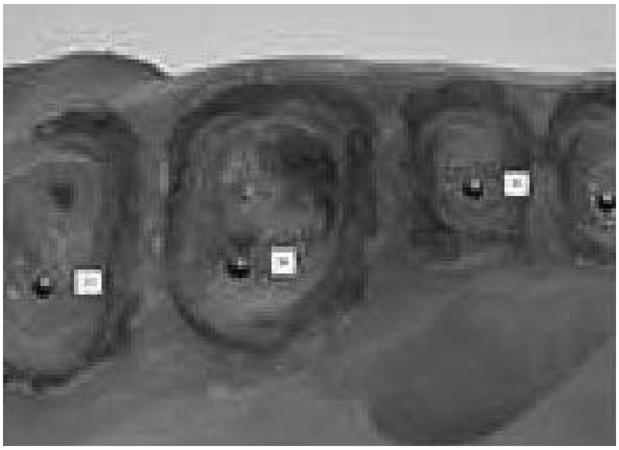

Fig. 4. *Digital impression occlusal view.*

Fig. 5. *3D-printed dental cast buccal view.*

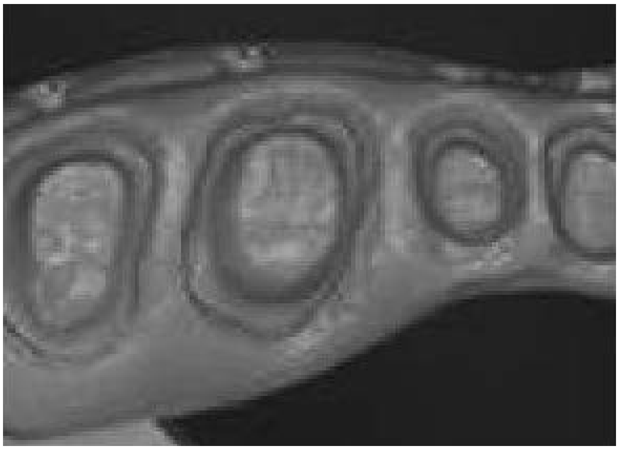

Fig. 6. *3D-Printed dental cast occlusal view.*

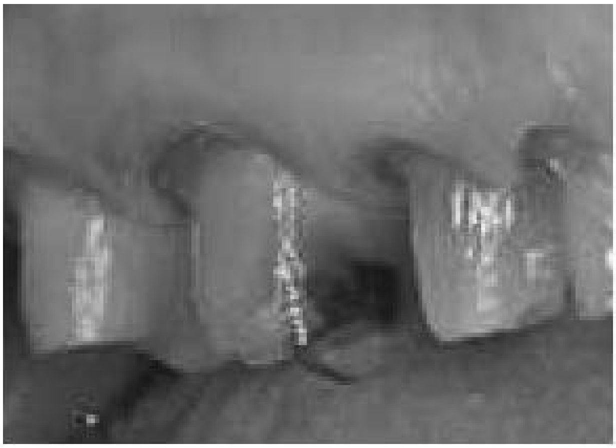

Fig. 7. *Periodontal tissues after 3 weeks of healing.*

Fig. 8. *Definitive porcelain fused to zirconia FDP.*

healing. However, irreversible changes may occur because of the heat degeneration leading to possible gingival retraction. To the best of our knowledge, no studies were published describing the RS as a gingival displacement technique.

While few and old articles have analyzed the effects of ES as a gingival displacement technique. Azzi et al. (6) analyzed clinically and histologically the effects of ES, retraction cord, and the rotary gingival curettage technique in dogs. Postoperative periods analyzed ranged from 6 hours to 14 days. The results showed that all methods induce some type of damage of a transient nature and that tissues heal after their use without any permanent loss of attachment. Gingival recession was greater and of probable clinical significance with the rotary gingival curettage technique, minimal with ES, and nonexistent with the cord. Another study showed that although there is loss of tissue soon after ES, 70 to 100% of the lost tissue is regained over a period of months (24). It has also to be considered that the histological effect of ES varies depending on the power output (25), frequency (26), the waveform selected (27) and size and shape of active electrode (28). These studies can roughly figure out the effects of RS on the periodontal tissues as a displacement technique, taking into account that Schoinohoriti et al. (29) found no statistically significant differences regarding lateral thermal damage and epithelial cell proliferation between ES and RS. Long term studies over a greater specimen are necessary to better analyze the RAGD technique. A detailed evaluation of the soft tissues response should be performed, considering different variables such as the periodontal biotype, systemic diseases and smoking habits.

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