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Short communication

A modified scan technique for multiple abutment teeth using the trim and lock function☆

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ABSTRACT

Objectives: To describe a new protocol for digital scanning of multiple abutment teeth using the trim and lock software tools.
Methods: A reverse workflow technique was used. Scanning was performed with the interim restoration in position. The abutment teeth were then trimmed from the scan. The retraction cord or interim restoration from either the first mesial or distal abutment tooth was removed and only that tooth was scanned, allowing the dentist to easily manage gingival displacement and keep the tooth dry from crevicular fluid and saliva. Consequently, the preparation margin remained visible and uncontaminated during the scan. The adjacent abutment teeth detected in the scan were deleted from it, and the scan was then locked using a tool of the scanning software. Next, the retraction cord or interim restoration of the next abutment tooth was removed, and only that tooth was scanned. The procedure was repeated until all prepared teeth were individually scanned.
Results: The technique presented here facilitated the scanning of multiple abutment teeth in a simple and predictable way by utilizing the trim and lock surface tools of the scanning software and helped in avoiding closure of the gingival crevice.
Conclusions: Splitting the scan for a complex case with multiple abutment teeth allows reliable 3D acquisition of the finish line of each abutment tooth. Therefore, this technique simplifies the full-arch intraoral scanning process and can improve treatment efficiency.
Clinical Significance: The trim and lock tool allows scanning of each prepared abutment tooth separately, transforming a full-arch impression into multiple single scans. This technique helps to easily manage gingival displacement and maintain an uncontaminated and dry preparation margin during the scan.

1. Introduction

Gingival displacement has an essential role in fixed prosthodontics as it enables the making of better impressions and allows the technician to clearly visualize the part of the tooth usually hidden under the gingival margin [1,2]. It is essential to record the finish line as well as the tooth finishing line to fabricate restorations with optimal marginal adaptation harmonious with the tooth and gingival anatomy. The most common technique for gingival displacement involves the use of single or double retraction cords soaked with a hemostatic agent, hemostatic retraction paste, or a combination of the two [3,4]. Use of modified interim crowns or impression trays to carry a light-body impression material in the conventional impression has been proposed [5,6] to obtain a more accurate impression of the finishing line.

The prerequisites of accurate digital scans are analogous to those of accurate conventional impressions. As an alternative to the light-body material used in the two-phase technique in conventional impressions, digital impressions require adequate tissue displacement to allow light to reach all the required sites of the abutment tooth [7]. Different techniques combining conventional and digital impressions [8] or using

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of interim restorations [9] have been proposed for gingival displacement during intraoral scanning. Nedelcu et al. [10] evaluated the finish line distinctness and accuracy of scans using seven intraoral scanners (IOS) and one conventional impression, analyzing mesh resolution, tessellation, topography and color effect of the IOS's, and concluded that some IOSs perform better than conventional impressions in vitro.

When multiple abutment teeth need to be scanned or recorded using conventional impression techniques, the timing of gingival displacement is critical to avoid early gingival collapse. For conventional impressions, one of the most popular techniques is to segment the primary impression of the dental arch made using rigid impression material into individual abutment tooth impressions [11].

Different scanning techniques and strategies have been recently introduced to improve both scan accuracy and efficiency for full-arch digital impressions [12,13]. These reports have analyzed different movements of the tip of the scanner to record a full arch impression continuously in a single scan. In this study we propose a simple and reliable technique using the trim and lock surface tools provided by an intraoral scanning software that allows the splitting of a multiple abutment teeth scan into many single abutment teeth scans.

2. Technique

The present technique can be used in any clinical scenario and on tooth preparation with any finish line using one or two retraction cords [14], a single interim crown [15], or other means (e.g., astringent retraction paste) for gingival displacement.

1 A reverse digital workflow technique [16] was used to make a definitive digital impression as follows:
  (a) The antagonist teeth were scanned.
  (b) The arch with interim restorations (pre-preparation scan) was scanned (both arches were scanned if both required restoration and the step for scanning the antagonist teeth was then skipped).
  (c) The scanning of the prepared teeth as indicated in the predetermined software workflow, was skipped going to last step. The maxillomandibular relationship was scanned and lateral and protrusive mandibular movements were recorded using a patient-specific motion scanner tool (Fig. 1A) with the interim restorations in position (Fig. 1B). Thanks to IOS software, the scan of abutment teeth (prepared teeth) will be in the same occlusal position as that of the interim restorations without having to record it on the abutment teeth. Laboratory design software programs such as Dental System (3shape A/S) automatically receive all these scans superimposed in a single folder in the following order: interim restorations scan, prepared teeth scan, maxillomandibular relationship scan and patient specific motion scan.
2 After static occlusion and the patient-specific motion were recorded, the regular workflow was resumed to and the area of the interim restorations was trimmed using a 1 mm brush trim tool, including approximately 1.5 mm of gingival tissue (Fig. 1C, D and Fig. 2A). Care was taken to retain as much keratinized gingiva as possible during abutment teeth trimming to allow the IOS software to accurately perform stitching/matching.
3 The tooth preparation was refined if required, and a retraction cord was placed into the gingival sulcus of the abutment teeth or the

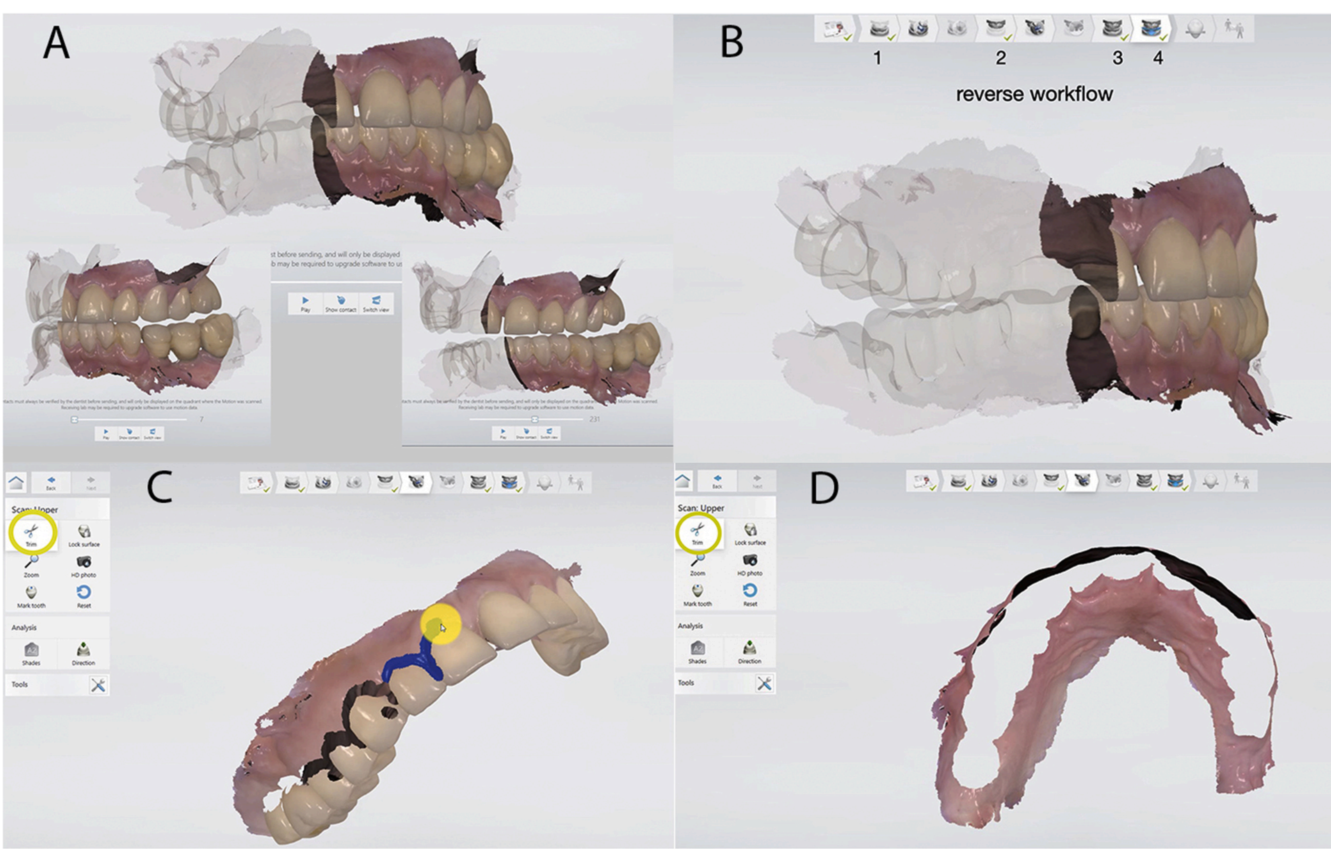

Fig. 1. (A) Patient-specific motion recorded with interim restorations in situ
(B) Reverse workflow: recording of the maxillomandibular relationship and patient-specific motion with interim restorations in situ
The numbers indicate the chronological order of the scans.
(C) Pre-preparation for trimming with preservation of as much keratinized gingiva as possible to allow the scanner to better triangulate the data with the master scan
(D) Maxillary prepared teeth with retraction cord in situ.

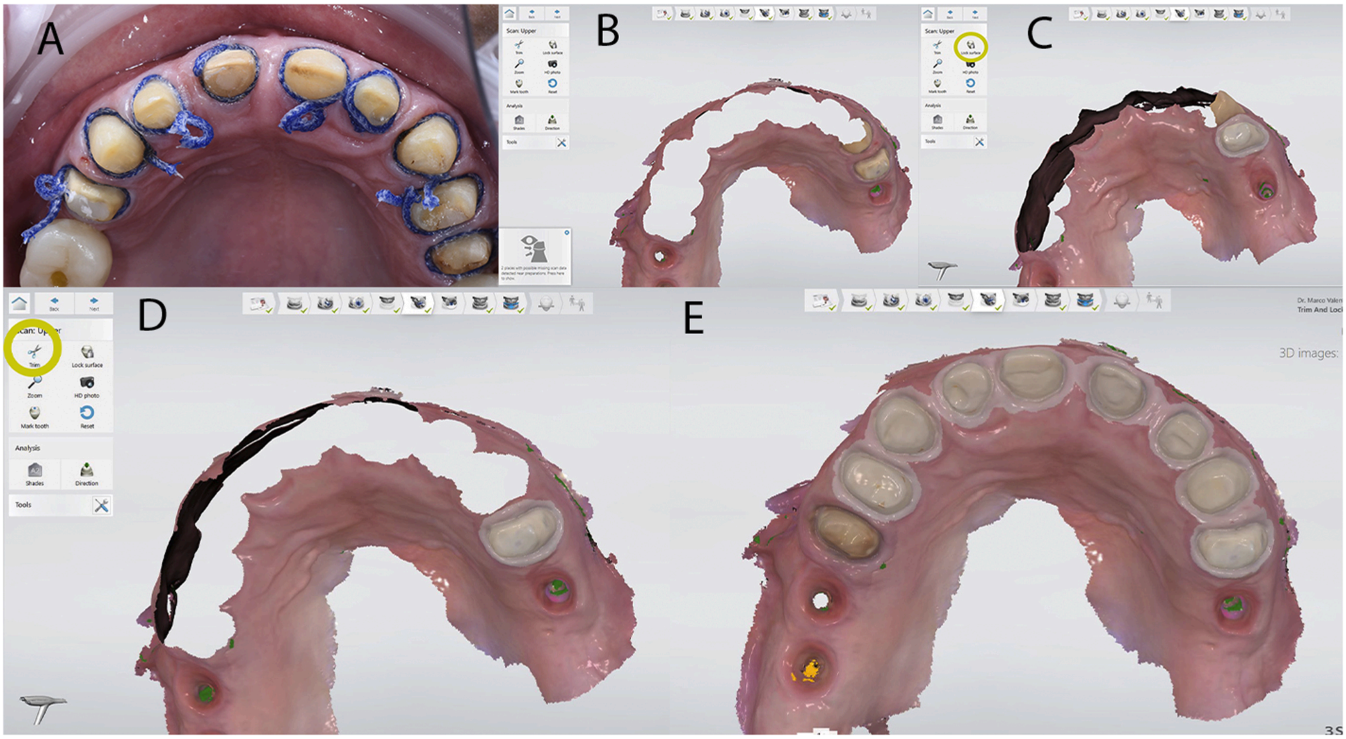

Fig. 2. (A) Pre-preparation for trimming. The prepared teeth can now be scanned next
(B) Scanning of the first prepared tooth with a part of the adjacent tooth
(C) Locking the scan of the prepared tooth using the lock surface tool of the scanning software
(D) Trimming the adjacent tooth in the locked scan of the first abutment tooth
The adjacent toot can be individually scanned next by repeating the procedure.
(E) Following the scan of the last prepared tooth, the locked scans of all abutment teeth are merged.

interim crowns were reseated, depending on the clinician's preference.

4 After a minimum of 4 min [17], the retraction cord or the interim restoration was removed from either the most mesial or distal prepared abutment tooth, following which the particular abutment tooth was scanned (Fig. 2B).
5 The scan was evaluated for appropriate scanning of the abutment. The abutment surface was locked using the locking tool provided by the scanner software (Fig. 2C). Thereafter, any teeth adjacent to this abutment tooth that were inadvertently included in the scan were trimmed from it (Fig. 2D).
6 The procedure was repeated for all the abutment teeth to be scanned (Fig. 2E), thus transforming the impression of an arch into multiple single-tooth impressions.

Once a clinician gains experience in using an IOS, the surfaces of two or three prepared teeth can be scanned simultaneously.

3. Discussion

An advantage of a digital impression over an analogous one for both patients and clinicians [18] is the possibility of interrupting the scan at any time and resuming it from the point at which it was paused. This is in contrast with the use of impression materials, where once an impression tray is inserted intraorally, one must wait for the material to harden before removing it.

The technique presented in this article utilizes the trim and lock surface tools of the scanning software to facilitate impression-making of multiple abutment teeth in a simple and predictable way while avoiding gingival crevice closure [19]. Scanning one tooth at a time allows the clinician to take time and precisely scan the important details of the tooth preparation margins without concerns regarding the collapse of the gingival margin around the remaining abutment teeth, which could be an issue when all the abutment teeth are scanned together. When a tooth preparation has a defined visible line of reference such as a shoulder or chamfer, identification of the finish line can be influenced not only by scanner accuracy or visualization of the margins, but also by the triangle density, level of triangle regularity and variations in height. Nedelcu et al. [10] found through their in vitro study that TRIOS 3 and CS3600 scanners provide higher finish line accuracy and distinctness that conventional impression.

Splitting the scan as described in this article, simplify the full-arch intraoral scanning process [20] and improve treatment efficiency. The artificial intelligence and algorithm of TRIOS software [21] recognize the previously scanned and locked surfaces and perform mesh triangulation without overlapping of the locked areas, which are used to reposition the scan of the trimmed surface. The effects of cropping and scanning on the scan accuracy remains unclear. Previous in vitro studies have revealed contrasting findings. Reich et al. [22] identified no substantial differences, while Revilla-León et al. [23] reported a decrease in the accuracy of the scan after cropping out of larger areas. Unlike the technique used in previous in vitro studies where the cropping was automatically performed by the scanner software, the technique proposed in this study required the trimming to be performed manually while retaining as many reference points on the surrounding keratinized gingiva as possible; further, every scanned prepared tooth was subsequently blocked to avoid overlapping. Revilla-León et al. recently concluded that blocking the area around mesh holes could maximize scanning accuracy [24].

The cross-arch distortion of the scanner compared with conventional elastomeric impressions is highly debatable. Most scientific literature presents in vitro data related to impression on implant [25], and the results of these accuracy studies cannot be extrapolated to the clinical scenario [26]. In vivo studies entail some biases owing to the use of metal reference aids [27], which can influence scanner accuracy [28]. Recent studies have reported no significant difference in the accuracy of conventional elastomeric impressions and that of digital impressions in different clinical scenarios [29,30]. They have also shown that the TRIOS scanner is one of the most accurate intraoral scanners available [31,32], performing well across different substrates: enamel, dentin, composite, and metal [33].

The intraoral scanner should not be considered a substitute for impression materials but rather a new way to collect information and help control all phases of a prosthetic workflow using the tools provided by an intraoral scanning software [16,34]. Future software updates for intraoral scanners [35] and new scanning strategies [36] will enable clinicians to design and develop more clinical protocols and treatment options for patients.

The technique presented has some limitations. First limitation is that although the authors did not find any clinical issue in the restorations fabricated using this procedure, there is no scientific data to support it.

Second, in cases of inadequate keratinized mucosa around the teeth, the trimming of the gingiva needs to be performed meticulously to facilitate stiching and triangulation performed by IOS software. Nevertheless, to our knowledge, previous studies explored scan strategies in terms of intraoral scanner movements and path, but did not consider the use of scanner software to split a multiple abutment teeth impression and maintain gingival displacement for each prepared tooth as in our study.

Further in vitro and clinical trials are required to understand how the trim and lock tools affect scan accuracy and compare the efficiency of the technique presented in this report with that of the conventional scanning methods.

4. Conclusions

This novel technique may enable the clinician to easily make digital impressions of multiple abutment teeth using the trim and lock surface tools of the scanning software. Scanning individual abutment teeth separately could prevent inaccuracy caused by the collapse of the marginal gingiva and thus improve operator scanning performance.

CRediT authorship contribution statement

Marco Valenti: Conceptualization, Methodology, Writing – original draft, Visualization. **Alessandro Valenti:** Writing – original draft, Writing – review & editing. **Davide Cortellini:** Writing – original draft, Writing – review & editing. **Johannes H. Schmitz:** Writing – original draft, Writing – review & editing. **Angelo Canale:** Conceptualization, Methodology.

Declaration of Competing Interest

Dear Prof. Lynch and Prof. Mangano, I am writing to submit our manuscript entitled, The trim and lock surface scan technique for multiple abutment teeth digital impression with intraoral scanner, for consideration as an Journal of Dentistry digital dentistry section article.

Each named author has substantially contributed to conducting the underlying research and drafting this manuscript. Additionally, to the best of our knowledge, the named authors have no conflict of interest, financial or otherwise.

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