Transferring emergence profile and position of interim restorative implant fixture

A novel digital technique

Juan Mesquida, DDS
International Dentistry Research Group, Palma de Mallorca, Spain

Diogo Firmino, CDT
Private Laboratory, Palma de Mallorca, Spain

Carmen Matji, DDS
Private Practice, Palma de Mallorca, Spain

Ignacio Ginebreda, DDS
International Dentistry Research Group, Palma de Mallorca, Spain

Israel Puterman, DDS
International Dentistry Research Group, Palma de Mallorca, Spain

Matthew J. Fien, DDS
International Dentistry Research Group, Palma de Mallorca, Spain

Alvaro Blasi, DDS, CDT
Department of Restorative Sciences, Dental College of Georgia at Augusta University, Augusta, Georgia, USA
Department of Restorative Dentistry, School of Dentistry, International University of Catalunya, Barcelona, Spain

Renaud Noharet, DDS, PhD
Department of Prosthodontics, University of Lyon, Lyon, France

Guillermo Bauza, PhD
International Dentistry Research Group, Palma de Mallorca, Spain
Faculty of Medicine, Health and Life Science, Swansea University, Swansea, UK

Correspondence to: Dr Juan Mesquida
C/ Rey Sanç 12, Local 12, 07004, Palma de Mallorca, Spain; Email: jmesquida@me.com

Abstract

The present technical article describes a protocol to digitally reproduce the emergence profile of an interim implant prosthesis (IP) and to transfer its macrogeometry into the definitive restoration. The purpose of this protocol was to minimize alterations in the gingival architecture developed during the interim restorative phase of a single implant that could potentially jeopardize its esthetic outcome. The process included obtaining an intraoral scan with the interim IP in situ, a duplicate of this intraoral scan that was used to capture the exact position of the implant, and an extraoral scan of the prosthesis. These data could then be imported into IOS software to create a model where the patients' soft tissue was incorporated with precision, allowing for the fabrication of a definitive crown with an optimal soft tissue adaptation. As there are few articles in the scientific literature that have reported a consistent method to replicate the emergence profile of an interim IP, the present technical article aims to highlight the potential of utilizing the emergence profile of an interim IP created by IOS software.

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Keywords

dental technology, digital mesh, digital workflow, emergence profile, interim prostheses, intraoral scanner, prosthodontics, restorative dentistry

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Introduction

Achieving an accurate implant digital impression represents a clinical challenge when intraoral scanner (IOS) acquisition of the fixture location and peri-implant soft tissue is to be performed.[1] Individual supramucosal architecture as well as the 3D position of the implant are of the utmost importance for a predictable outcome for the future definitive restoration.[2] In addition, the emergence profile of an implant restoration will affect the longevity and predictability of the treatment,[3] supporting and preventing soft tissue collapse and helping to maintain an ideal anatomy for optimal esthetic outcomes.[2,4]

To develop an ideal emergence profile, a careful design and fabrication of the interim restoration is critical to the final treatment result.[5] Different factors such as the vertical and horizontal position of the implant as well as the peri-implant soft tissue architecture and characteristics must be taken into consideration to provide the appropriate support for or pressure on the gingiva.[6-8] A biologically driven subgingival restorative design is needed to optimize the architecture of the peri-implant tissue and to maintain its stability over time.[3,6]

Many techniques have been described to fabricate a restoration that complies with the concepts described by Su et al for the adequate development of peri-implant subgingival contours (ie, critical and subcritical contours).[9] Analog techniques for impression acquisition involve the fabrication of a customized impression coping that incorporates a duplicate of the emergence profile developed for the interim restoration.[7,10-13] However, some limitations are associated with this, including the time consumed, the usage of resins,[14] and the soft tissue architecture disturbances produced during the process.[15] Digital technology and the acquisition of the intraoral topography with an IOS could potentially overcome these limitations; thus, several workflows have been proposed.[1,16-22]

The use of a regular scan body has been suggested to accurately record the implant position; however, this does not prevent the collapse of the soft tissue during the scan process[23] and can lead to inaccuracies in the soft tissue architecture when the intraoral scans are performed repeatedly.[24] To capture the emergence profile and facilitate the transfer of the transmucosal morphology of peri-implant tissue, some protocols use a combination of analog and digital workflows to customize the scan body.[16,18] Various authors have suggested using the inverse scan body concept for single tooth scenarios[20] as well as for edentulous patients requiring a full-arch restoration[25] in order to accurately reproduce the emergence profile for an implant definitive restoration. Alternatively, several other authors have suggested scanning the provisional restoration extraorally for an accurate reproduction of the critical and subcritical contours; however, these authors fail to provide a complete description of their protocol,[19,22] or utilize non-dental software,[1] or make it difficult for the broad range of dental professionals to access prototype bases and company-limited scan bodies.[21] Therefore, an effective, fully digital workflow is still required that uses a standard dental software program and regular scan bodies to accurately transfer the emergence profile and position of the interim restorative implant fixture, thereby supporting the gingival architecture.

The aim of the present technical report is to describe a fully digital workflow to precisely reproduce the emergence profile from an interim to a definitive prosthetic restoration that accurately registers the gingival architecture. A clinical case of a single tooth replacement is presented to illustrate the application of this novel technique.

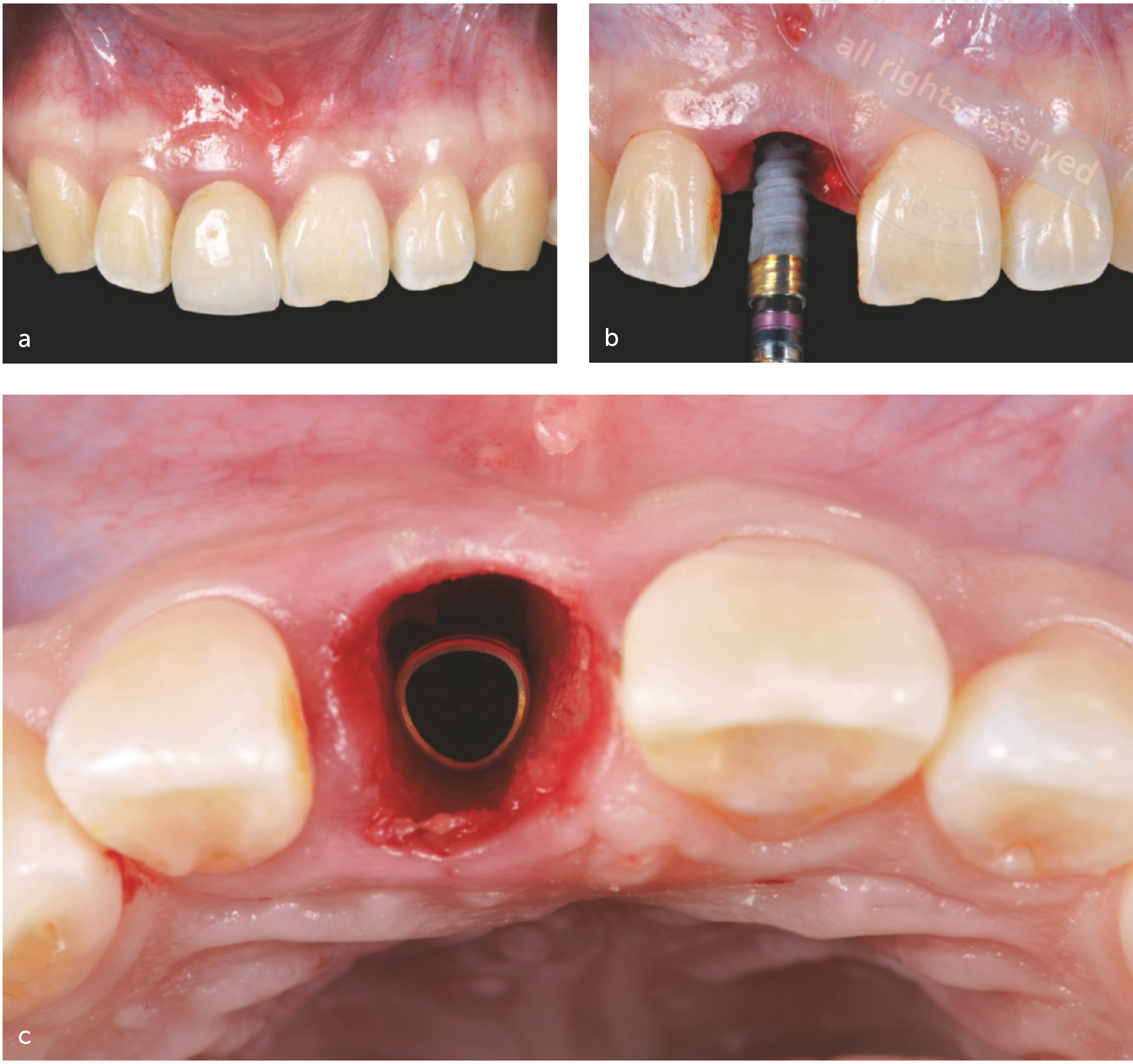

Fig 1a to c Preoperative view of esthetically compromised maxillary right central incisor (a). Implant placement following manufacturer's protocol (b). Implant placed (c).

Case report

A 25-year-old patient presented with a failing maxillary right central incisor with a previous history of traumatic injury with endodontic treatment, apical surgery, and a ceramic crown. Atraumatic extraction was performed to prevent further damage to the soft and hard tissue. Immediate implant placement (Nobel Biocare N1 system; Nobel Biocare, Zurich, Switzerland) was performed by means of guided surgery (Fig 1) following the manufacturer's protocol. An interim restoration was placed after an adequate shaping of the emergence profile (Fig 2).[4] Several follow-up appointments were required to

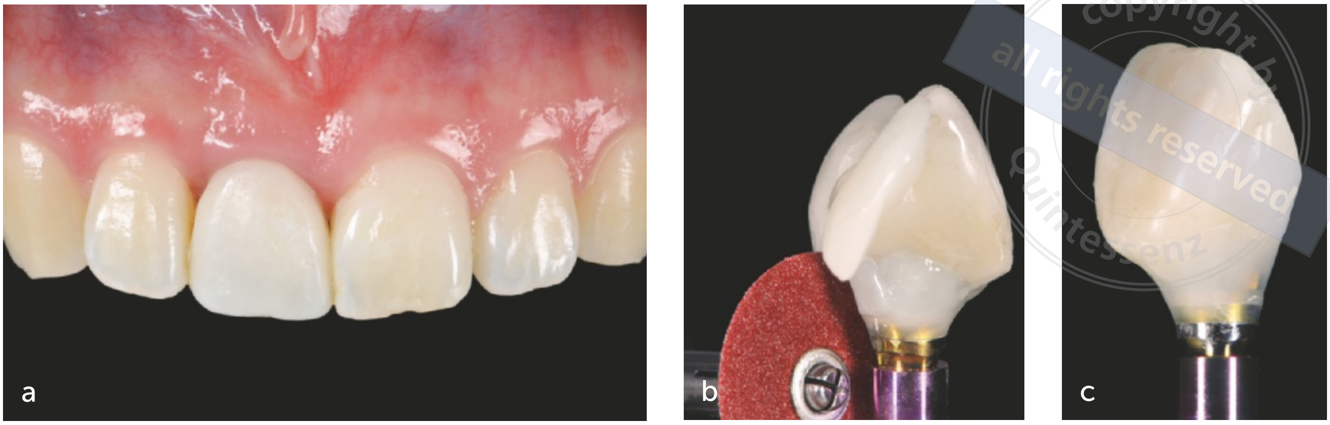

Fig 2a to c Interim restoration in place (a). Shaping of interim restoration using a polishing disc (b). Shaped interim restoration (c).

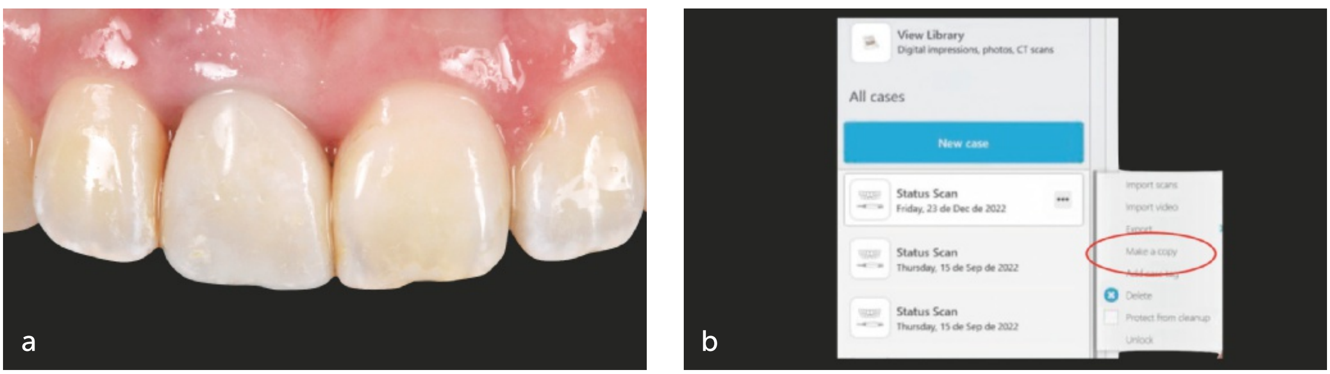

Fig 3a and b Six-month postoperative view prior to intraoral scanning (a). Software screenshot of "Make a copy" option (b).

modify the emergence profile in order to obtain an esthetically pleasing gingival architecture. Six months after implant placement, the patient presented with acceptable tissue healing and gingival architecture (Fig 3a), and the final restoration was fabricated utilizing the following protocol:

Clinical technique

Clinical scanning protocol

1. Acquire an intraoral scan (Trios 3 IOS; 3Shape, Copenhagen, Denmark) of the maxillary dentition with the interim prostheses in place according to the manufacturer's scanning guidelines to generate a standard tesselation language (STL) file, named STL 1.
2. Duplicate the STL 1 file using the "Make a copy" option of the IOS software (Trios 3) to reduce accuracy errors from the acquisition of repeated scans[24] and to avoid the superimposition of significantly different STL files (Fig 3b). The STL 1 file will serve to register the position of the provisional and the peri-implant tissue architecture when the provisional is in place. In addition, the STL 1 file will be used as a reference to merge the files that follow of a mesh with the same pressure applied by the interim restoration on the peri-implant tissue.

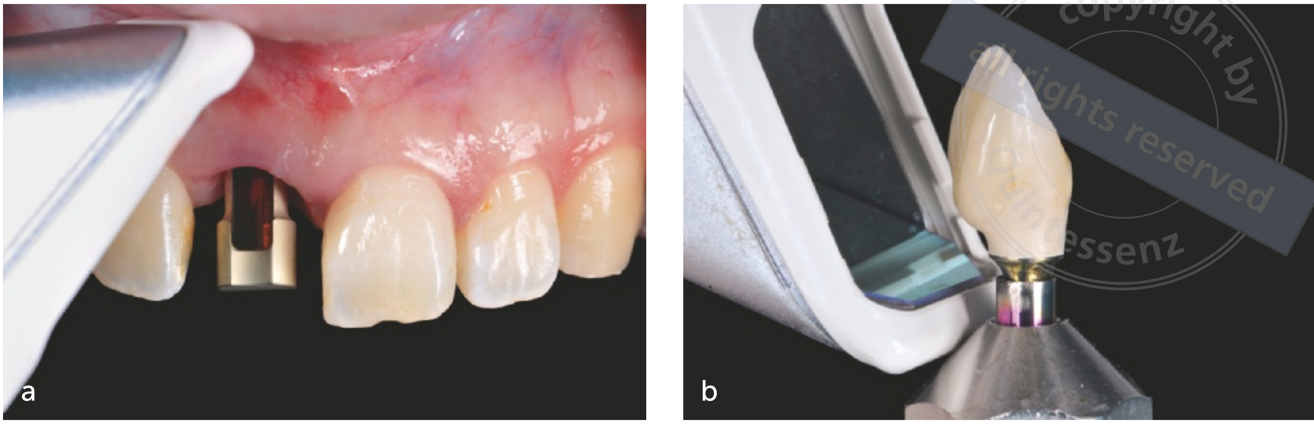

Fig 4a and b Scan body in situ (a). Implant analog-adapted interim restoration extraorally scanned (b).

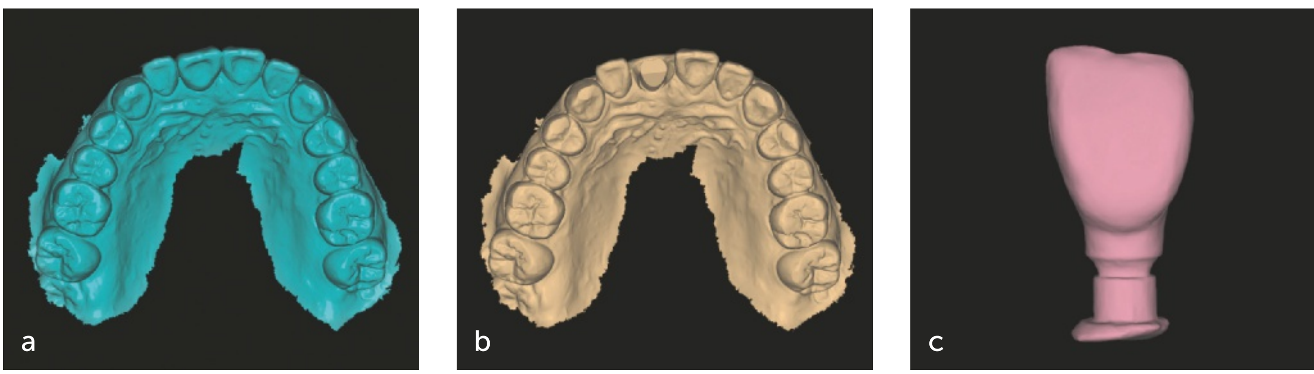

Fig 5a to c STL files: Full-arch scan with interim restoration in situ (STL 1; a). Duplicated scan with scan body in place (STL 2; b). Implant analog-adapted interim restoration extraorally scanned (STL 3; c).

3. In the duplicated file, generate an "opening" in the mesh where the implant position locator will be captured to locate the exact implant position. Utilize the "Erase" tool to remove the clinical crown from the interim prostheses. Re-scan the erased area after removal of the interim prosthesis and placement of a scan body (Position Locator N1 Nobel; Nobel Biocare, Zurich, Switzerland) to generate a second file, named STL 2 (Fig 4a).
4. Acquire a scan of the interim prostheses adjusted to an implant analog (IOS Implant Replica N1 system, Nobel Biocare) extraorally to generate a third file, named STL 3 (Fig 4b). The STL 3 file will provide the specific subgingival contour information developed by the clinician during the interim prostheses stage.[21]
5. Send the three files (STL 1, STL 2, and STL 3) generated by the three scan acquisitions (Fig 5) to the laboratory using a compatible communication platform (3Shape Communicate; 3Shape).

Laboratory superimposition (merging) protocol

6. Import all three files (STL 1, STL 2, and STL 3) into a dental CAD software program (DentalCAD; exocad, Darmstadt, Germany). Rearrange all three STL files into the same virtual plane using the

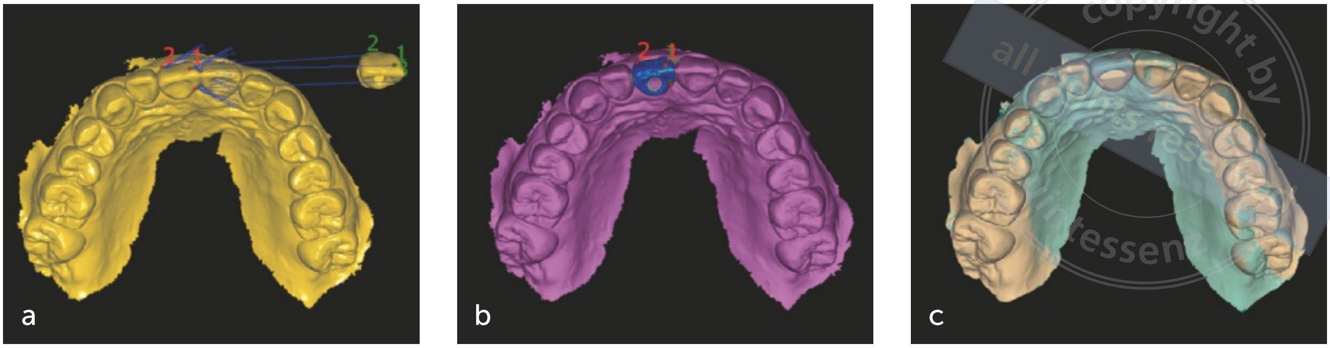

Fig 6a to c STL 1 and STL 2 merging reference points (a). STL files merged with "Best fit matching" algorithm (b). STL 1, STL 2, and STL 3 merged into the same virtual plane (c).

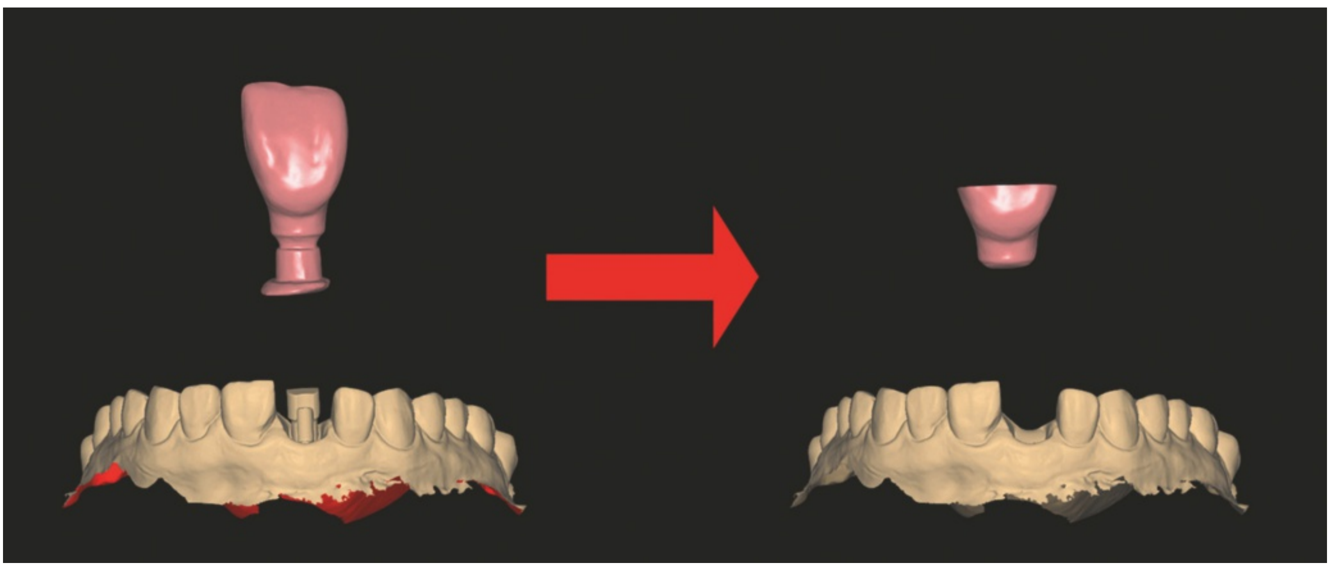

Fig 7 Modified STL 2 and STL 3.

mesh alignment technique and the "Best fit matching" algorithm available in the software (Fig 6).

7. Erase the scan body region from STL 2, and, with the same software tool, delete the implant analog and supragingival regions of STL 3, maintaining the critical and subcritical parts of the interim prostheses in the mesh (Fig 7).
8. Import the modified STL 3 file as an antagonist impression and the trimmed STL 2 file as the diagnostic "wax-up scan" model to produce a new digital model that includes subcritical contour information. Use this modified digital mesh as if it was a restoration that can be adjusted normally with the CAD software tools, required for the creation of the new mesh with the incorporated subcritical contour information.
9. Adjust the modified digital mesh using the static occlusal contact adjustment tools from the CAD software at 0 mm to obtain a model incorporating the non-collapsed soft tissue profile to create a new file, named STL 4 (Fig 8). Note

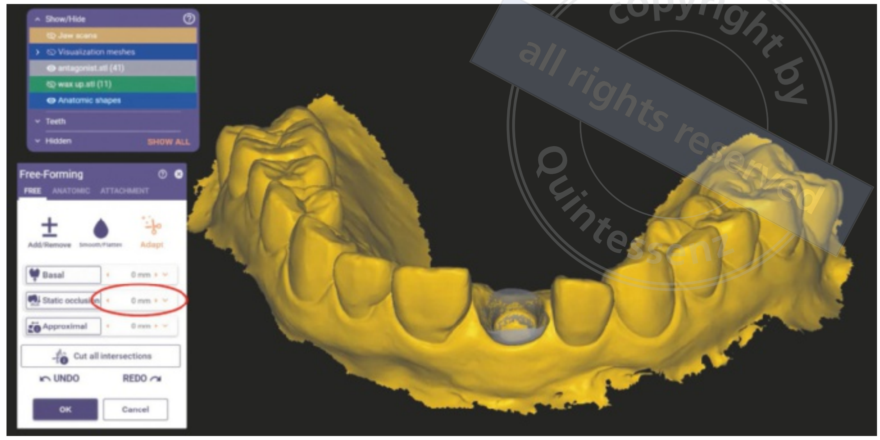

Fig 8 Adjusted digital mesh with static occlusal contact at 0 mm (STL 4).

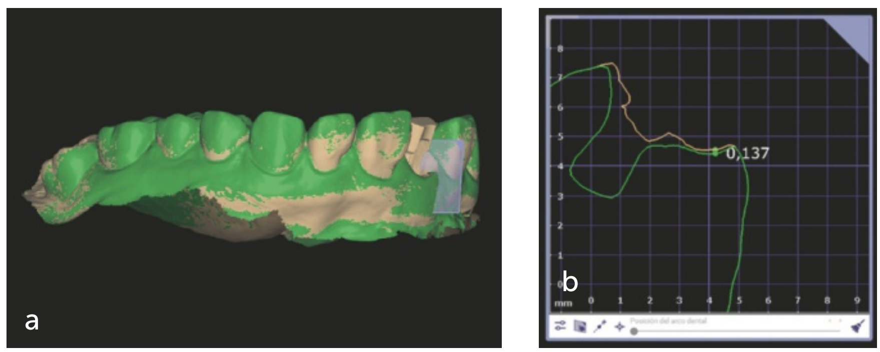

Fig 9a and b Merged STL 2 (brown) and STL 4 (green) files (a). STL 2 (brown) and STL 4 (green) soft tissue profiles (b).

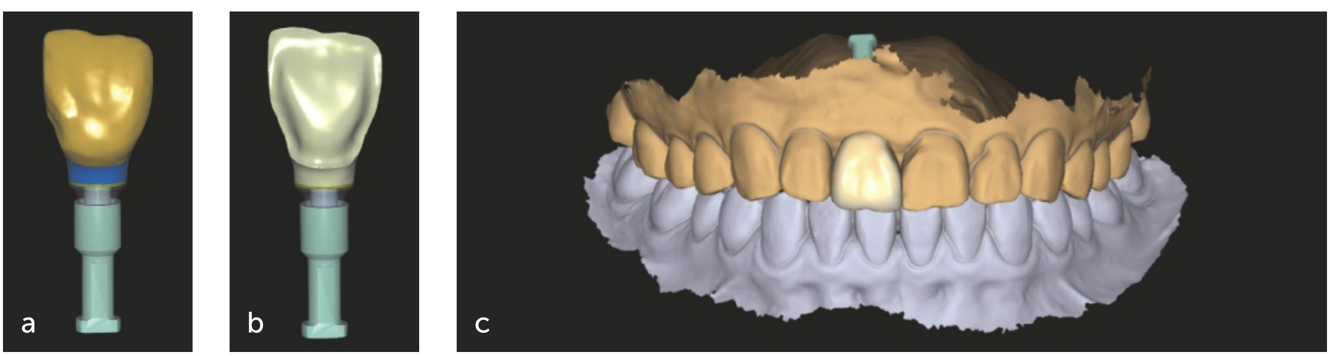

Fig 10a to c Definitive restoration design (a). Definitive restoration cutback (b). CAD definitive restoration (c).

the significant soft tissue profile differences when compared with the scan body-acquired profile in STL 2 (Fig 9).

10. Import the resulting file into the dental software to design the restoration (zirconia in this case; Fig 10). The specific features designed by the clinician at critical and subcritical regions will now be incorporated into the definitive restoration.
11. Fabricate a final prosthesis respecting the subcritical profile of the interim prostheses together with the desired esthetics.

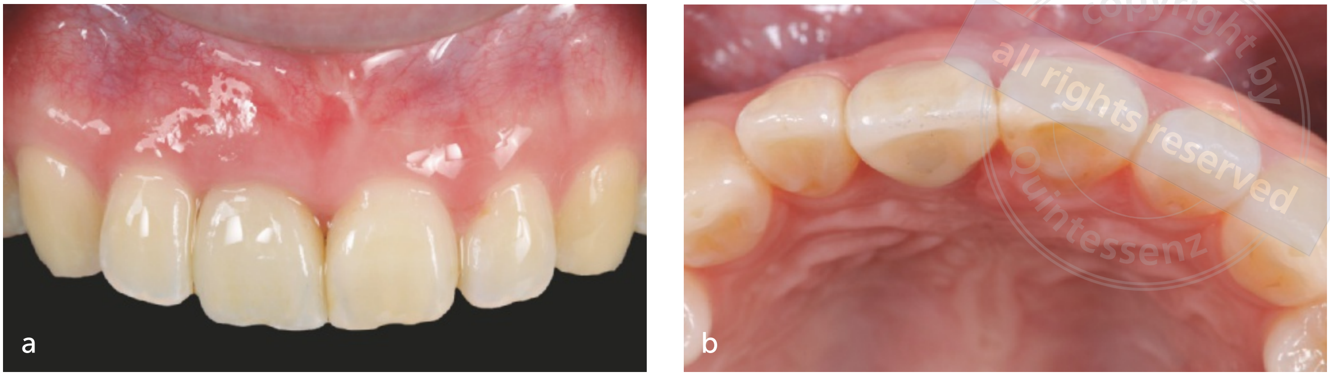

Fig 11a and b Frontal (a) and occlusal (b) views 6 months after final prosthetic delivery.

At the 6-month follow-up, the patient had maintained optimal peri-implant hard and soft tissue stability (Fig 11).

Discussion

The present technical article describes a fully digital workflow to accurately reproduce the emergence profile of the interim restorative implant prosthesis (IP) into the definitive restoration, registering the clinically modified gingival architecture. An intraoral scan with the IP in situ, a duplicate of this intraoral scan (modified and used to capture the exact position of the implant), and an extraoral scan of the prostheses are imported into IOS software to create a virtual model where the soft tissue developed during the interim process is incorporated with sufficient accuracy for the fabrication of an optimal definitive crown.

Previous studies have suggested the reproduction of the emergence profile of the interim restoration through a combination of analog and digital techniques,[18] recreating the critical and subcritical contours of the interim restorative IP by scanning it extraorally, but without using any scan body to obtain the exact implant position; however, a mesh for the soft tissue is not created, and this cannot be modified retroactively by the dental technician. The workflow described in this article is fully digital and generates a model for the dental technician to fabricate the definitive crown.

In a different way to what is described in this article, Joda et al described the "Individualized Scan Body Technique," personalizing every single scan body with pattern resin to reproduce the emergence profile accurately.[16] Even though the reproduction is correct, it is not a fully digital workflow and requires a new scan body per procedure due to potential deterioration. In addition, the technique of those authors lacks a step in the protocol to create a digital mesh that considers the gingival tissue supported by the interim restoration. Following a similar principle, Gonzalez-Martin et al described the inverse scan body concept.[20] Their workflow relies on the fabrication of an inverse scan body for every single case to be scanned extraorally, thereby allowing for an exact implant localization. Although it is true that a fully digital workflow is described by those authors, the scan body prototype could be difficult to obtain because commercially inverse scan bodies for each implant company were not yet available at the time of publication of this article. Papaspyridakos et al also used a similar reverse scan body concept in full-arch prostheses.[25] Again, their technical description, like that of Joda et al, lacks the instructions to create a digital mesh that considers the gingival tissue supported by the interim restoration, which is crucial to fabricate an adequate definitive restoration.[16,20]

In addition, Dada et al published a digital workflow able to reproduce the emergence profile of the interim restoration and create a mesh that replicates the tissue surrounding the implant.[21] However, to follow the protocol of these authors, company-specific prototype bases and company-specific scan bodies are an essential requirement, which limits the access for a broad range of dental professionals. The use of accessible and interdisciplinary dental software is also critical to obtain appropriate results.[26] Monaco et al used a very similar technique to that used by the present authors; however, they acknowledged the non-dental software as a limitation of their study and recommended future development to improve the convenience of the technique.[1] In a recent article, Agnini et al described a fully digital workflow that involved the fabrication of a final restoration according to the modified emergence profile.[22] However, these authors failed to specify the software utilized and did not provide details of the mesh creation process. In the workflow presented in this article – and differently to that described by Agnini et al[22] – the STL 1 file is duplicated to ensure the accumulation of a minimal number of accuracy errors when an intraoral scan is repeated as well as to avoid the superimposition of significantly different STL files.[24]

The dental software utilized and described in this technical report is common, is accessible to dental professionals, and allows for the complete workflow to be performed in simple steps. One of the most important steps described herein is the Boolean operation performed to create the mesh that allows the fabrication of the definitive restoration accurately (steps 8 and 9). Liu et al elegantly describe a very similar process in their article.[19] However, those authors utilize a non-commercially available software program and do not specify the instructions to create the mesh, which are required for the implementation of their technique. Moreover, they describe the creation of this mesh including soft tissue contours after the creation of the definitive restoration.[19]

Conclusions

The technique described in the present case report allows for the reproduction of the temporary crown emergence profile developed in the interim stage and the incorporation of its morphology into the definitive restoration. The software utilized for this technique is widely utilized in the dental laboratory setting and can be implemented with any type of implant system.

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