Case Report

Dimensional changes in soft tissue as a plausible cause for error in computer-aided design and computer-aided manufacturing stent-guided implant osteotomy

ABSTRACT

Dental implants have been in vogue for more than three decades as a successful mode of rehabilitation of lost dentition. With time, there have been updates in methods and science including a positive tilt toward incorporation of digital technology into treatment protocols. This report elucidates a rare case of faulty osteotomy preparation through a computer-aided design computer-aided manufacturing stent that was detected and corrected before implant placement. The manuscript also emphasizes the possible shrinkage of soft-tissue graft beyond the normal postulated time frame and the importance of periodical checks on the drilling protocol throughout the flapless placement procedure even though it may have been seamlessly planned on the digital platform.

Keywords: Computer-aided design computer-aided manufacturing guide, connective tissue graft, dental implant, virtual planning

INTRODUCTION

The concept of integration of titanium to living osseous tissue, as introduced by Brånemark has revolutionized rehabilitation of lost dentition. With time, there have been updates in methods and science including a positive tilt toward incorporation of digital technology into treatment protocols.

Digital planning and placement of dental implants have been one of the fastest-growing fields of implant dentistry.

It involves capturing data through cone-beam scans and integrating the same through specialized software to dental or intraoral scans. The use of this technology helps the clinician to adopt a more restoratively driven approach compared to the earlier practiced, available bone-driven approach. Computer-aided design and computer-aided manufacturing (CAD-CAM) technology provides for a 3-D-printed template that allows for osteotomy preparation in the mouth as per the virtual plan on the software where the depth, angulation, and axial inclination of the implant are planned as per the restorative needs of the case. A CAD-CAM fabricated surgical guide that satisfactorily reproduces virtually planned implant positions can play a significant role in the success of implant-retained prosthetic solutions.[1]

The prosthesis as desired by the clinician is mapped onto the digital platform and the same is then related to the available bone and soft tissue allowing for decisions to be made regarding the practicality of the original plan. This is then evaluated from the biological, biomechanical, and

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esthetic standpoint. Finally, this is verified by the clinician for adequate transfer of protocol from the digital to the clinical scenario. Modifications may have to be stitched into the original plan as per necessities of each case (prosthetic or surgical). These have to take into account all aspects of surgery and prosthetics such as (A) mouth opening, (B) bone type, (C) soft-tissue type and thickness, (D) implant dimensions, (E) type of prosthetic design, and (F) opposing dentition just to name a few.[2]

There are differences that exist in the degree of reliance on a digital workflow that is incorporated into the entire case from surgery to prosthetics, and this rests with the clinician.

CAD CAM guides may be classified according to the osteotomy protocol adopted – (A) pilot drill guides, (B) complete osteotomy guides, or (C) implant placement guides and also according to their mode of retention and support – (A) tooth supported, (B) tooth and tissue supported, or (C) tissue supported.

There are cases where the available tissues may have borderline dimensions which need augmentation at some point in time and the clinician may choose to adopt augmentation protocol alongside CAD CAM-guided placement. In this approach, the virtual plan needs to take this into account and integrate it into the master plan.

Augmentation may be required in some cases for the soft-tissue component alone. This is best done either before the implant placement or after as per clinical judgment based on available scientific evidence. The augmentation of soft tissue for the edentulous segment may be done with free gingival grafts or subepithelial connective grafts.[3]

Shrinkage of soft-tissue grafts has been reported in literature with the most appreciable changes at around 24 weeks postoperative.

CASE REPORT

A healthy male patient 65 years of age with no significant medical history consulted this facility for the replacement of broken teeth in the lower right quadrant. Teeth #44 and #46 were mutilated.

Clinical examination revealed retained root pieces in both regions. Cone-beam computed tomography (CT) scans were requisitioned. Scans showed retained root pieces in #44 and #46 [Figure 1].

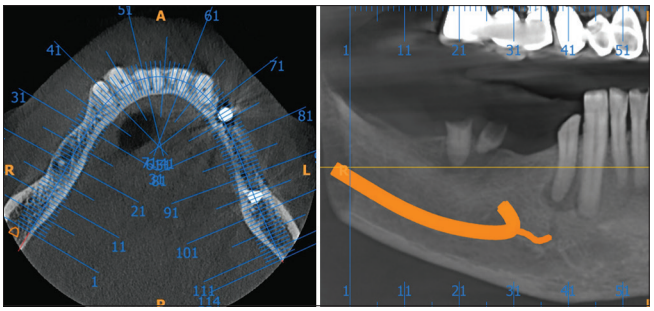

Figure 1: Baseline scan axial and sagittal section

The plan was to stage the procedure with extractions and socket + buccal veneer grafting at Stage 1 and implants at Stage 2 to be placed through a CAD-CAM stent.

The patient was informed of the possibility of a soft-tissue graft either before or after implant placement to augment the tissue quality.

At Stage 1, local anesthesia (lignocaine Hcl 2% with adrenaline 1:200,000) infiltration was done following which a crestal incision placed to expose the site. The said root pieces were extracted with minimal trauma to the surrounding tissue. Perforations were made in the buccal cortex with a small round tungsten carbide bur to increase vascularity for the graft. Carbonate apatite (Mineross XP, Biohorizons USA) of porcine origin with autogenous cortical shavings was used as the biomaterial and was covered using a resorbable collagen membrane (Memlok, Biohorizons USA), secured with periosteal sutures. Flap closure was done using 5,0 polypropylene (Prolene, Ethicon).

Healing was uneventful. After 2 months, soft-tissue augmentation as planned to increase the keratinized component at the buccal aspect of the said quadrant by way of a subepithelial connective tissue graft.

The same was carried out under local anesthesia, followed by uneventful healing.

After an additional 3 months of waiting, a cone-beam scan was obtained. This showed satisfactory hard-tissue dimensions for the placement of implants.

A virtual treatment plan was formulated using 3 Shape implant studio software to place a three-unit screw-retained prosthesis on two implants in #44 and #46 by way of a CAD-CAM stent [Figures 2 and 3].

Intraoral scans were obtained and data sent to the laboratory for fabrication of a CAD-CAM stent (part tooth, part tissue borne). The stent was checked for accuracy of fit before the

procedure by way of windows made over the incisal or occlusal aspect of teeth to assess complete seating of the same.

On the day of implant placement, local anesthesia was infiltrated (lignocaine Hcl 2% with adrenaline 1:200,000), the CAD-CAM stent was placed and a rotary tissue punch used at 25 RPM to remove the crestal soft tissue. Osteotomy preparation was started for both implants as per the virtual plan which involves drilling to predetermined depths with diameter dedicated drills and sleeves (Biohorizons, USA) [Figure 4].

Both implant osteotomies progressed till the penultimate drill diameter. At this stage, the mesiodistal angulation did not look satisfactory for implant in site #44. At this stage, the stent was removed; the drill inserted into the osteotomy at #44 and an intraoral radiograph obtained.

This showed the osteotomy with a distal tilt at the crestal, thereby placing the future implant in an unfavorable position from the prosthetic standpoint and too close to the natural tooth apex at the mesial aspect [Figure 5].

Minimal mucoperiosteal flaps were raised over both osteotomy sites before implants were inserted to verify the buccolingual axis at the crestal region.

A Lindemann bur was used to correct the osteotomy in the mesiodistal axis, and the implant placed free hand (Tapered laserlok, Biohorizons USA) [Figure 6].

Some autograft was placed on the mesial aspect of the osteotomy before implant placement. The implant in #46 was placed through the stent as planned (Tapered laserlok, Biohorizons USA).

There was no immediate obvious reason for this error in the mesiodistal axis. A 5 mm × 5 mm buccal window was cut out in the buccal flange of the CAD CAM stent in #45 region and the same re-seated. This threw up an interesting finding; there was a significant space between

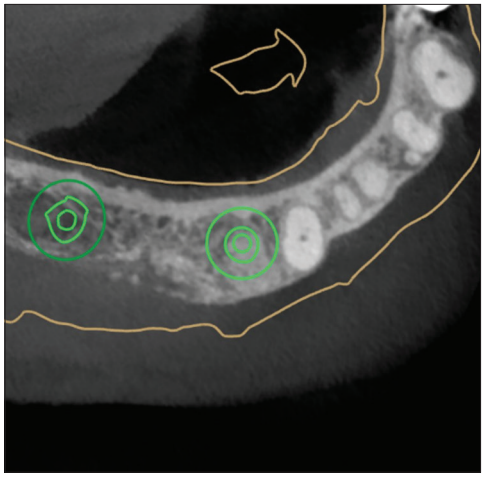

Figure 2: Digital virtual plan in axial section

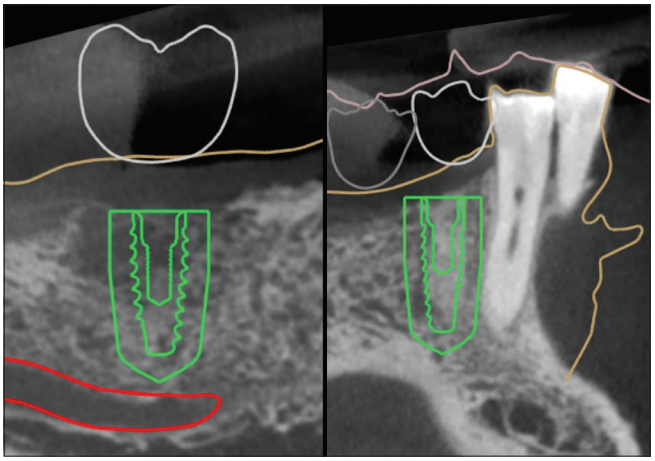

Figure 3: Digital virtual implant position in sagittal section

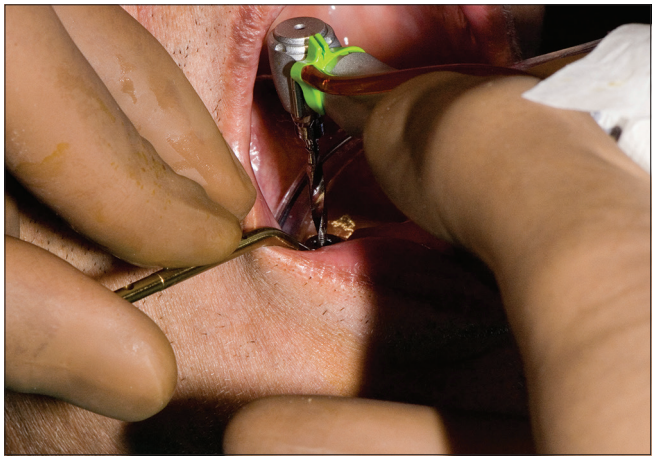

Figure 4: Osteotomy through the computer-aided design and computer-aided manufacturing stent

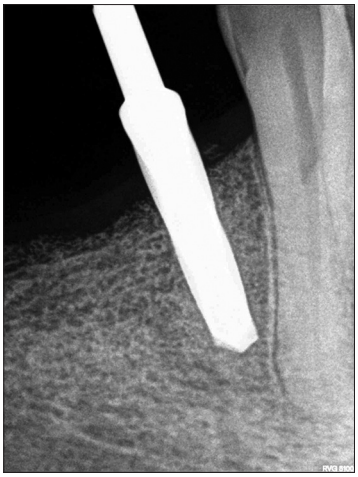

Figure 5: Implant drill showing error in mesiodistal axis

the intaglio surface of the stent and the underlying buccal soft tissue. Upon exertion of some amount of pressure from the crestal, this space decreased, which means there could have been slight movement in the stent on pressure from the handpiece, which was not evident as such because the distal aspect of the stent was firmly seated on the crest of the ridge.

Gingival screws were placed on both implants and the mini flaps sutured using 5,0 Vicryl (Ethicon).

Healing was uneventful, and after a waiting period of 3 months, the screw retained prosthesis was fabricated and inserted as per the original plan [Figures 7 and 8].

DISCUSSION AND SUMMARY

A systematic review of 2359 articles by Tahmaseb *et al*. showed errors that ranged between 1.12 and 4.5 mm at the crest and between 1.39 and 7.1 mm at the apex when implants were placed through a CAD-CAM stent by the flapless approach. This may be significant when planning implants in narrow interdental spaces with close proximity to adjacent roots and other anatomic structures.[4]

The benefits of flapless implant placement include minimally invasive procedure with faster return to normalcy from the patient's perspective. From the biologic perspective, it offers the advantage of minimal to no damage to the underlying bone due to the preservation of periosteal vascularity. The disadvantage if stated would include the possibility of heat generation in deeper sites and the inability to visualize any anatomical structures while drilling.[5]

Kim *et al*. measured differences between free gingival grafts and subepithelial connective tissue grafts for shrinkage. They postulated that vertical contraction of connective tissue free gingival autograft was 55% and 29%, respectively, 24 weeks after the surgical procedure.[6]

Loubele *et al*. found bony dimensions to be underestimated after measurements were taken from several CT scans.[7]

Likewise, Suomalainen *et al*. reported errors in CT image captures when used for measurement of bone dimensions. These errors become even more significant when planning implants in cases with borderline available bone tissue.[8]

Cifcibasi *et al*. reported an almost equal shrinkage of free gingival grafts in both horizontal and vertical vectors at 90 days.[9]

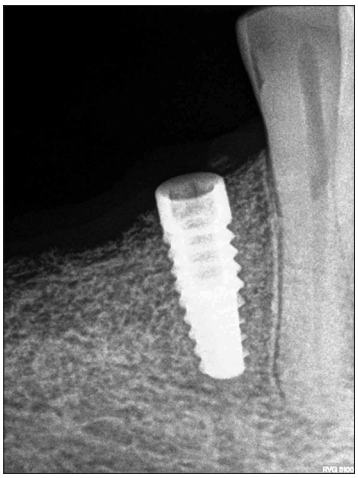

Figure 6: Implant placed in the correct position

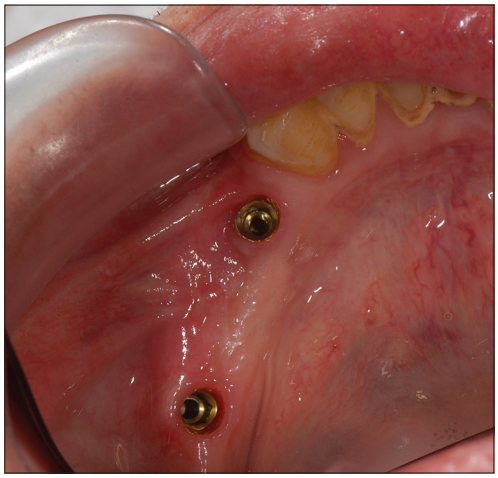

Figure 7: Osseointegrated implants

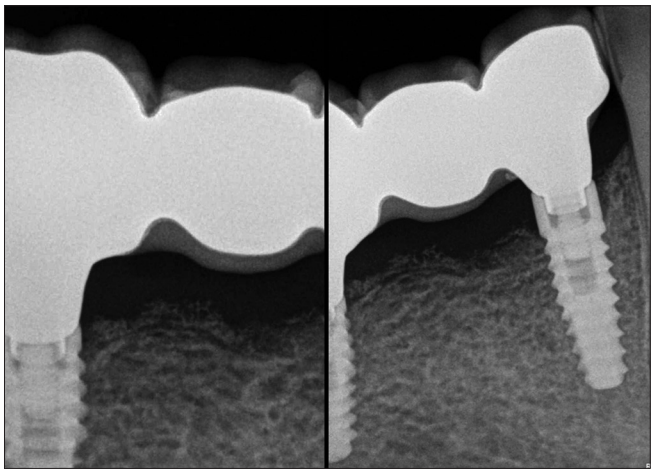

Figure 8: Screw retained prosthesis at 6-month follow-up

There are no causes that we could ascertain with surety, which resulted in the error mentioned in this report. Plausible reasons are as enlisted:

1. Lack of proper retention of the tissue supported distal extension
2. Shrinkage of the soft-tissue graft resulting in a misfit
3. Errors in digital data acquisition from intraoral scans or the CT scans
4. Errors in digital printing of the guide.

We use the term plausible as it is virtually impossible to pinpoint the single cause responsible, but nevertheless, this report highlights the possibility of errors creeping into clinical practice even though meticulous digital planning and technology is incorporated.

This case also throws some light on a few interesting points, which may have a significant impact on the way virtual planning is carried out for implant placement:

a. Windows are important not only over teeth but also over soft tissue to verify seating and retention of CAD-CAM guides where the distal extension of the guide is completely tissue supported (a situation similar to Kennedy Class I whether unilateral or bilateral)
b. The use of bone anchor pins may be advantageous in bilateral posterior tissue-supported guides [Figure 9]
c. The soft tissue that was grafted possibly showed shrinkage, which was unexpected at 16 weeks after the procedure and thus unaccounted for
d. Soft-tissue procedures if required should be undertaken after placement of implants and before the prosthetic phase to circumvent any such unforeseen event
e. There was a delay of 3 weeks between the virtual plan and the implant placement; this should ideally be much shorter
f. Areas with a greater thickness of soft tissue preferably should not be used to support our guides as they may undergo some amount of distortion under pressure
g. Despite high success rates reported with virtual planning incorporating digital technology for dental implant placement, errors may occur, thus is suggested that radiographic and clinical verification be carried out after the pilot drill and before implant insertion.

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Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

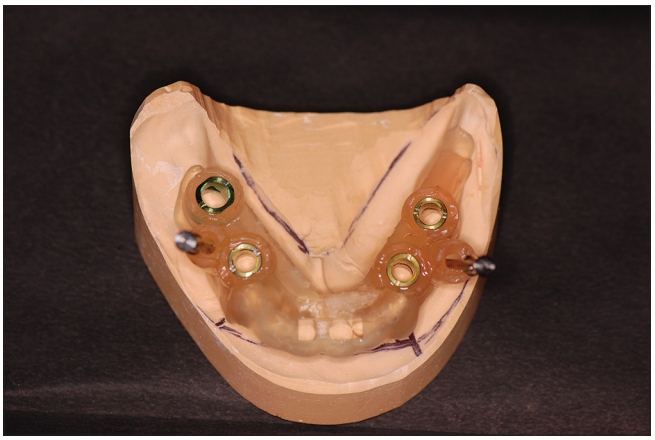

Figure 9: Bone anchor pins for tissue-supported distal extension

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Conflicts of interest

There are no conflicts of interest.

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