

Vertical Bone Augmentation of the Posterior Mandible with Simultaneous Implant Placement Utilizing Atelo-Collagen-Derived Bone Grafts and Membranes

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Abstract

Vertical bone augmentation of the posterior mandible followed by delayed implant placement and restoration remains a clinical challenge in dentistry. Commonly, a 2-stage approach is performed where first, a grafting procedure is performed with a typical xenograft/autograft mixture and an expected healing period of 9 months. Only thereafter can implant placement and restoration accomplished with a total treatment time upwards of 1-1.5 years. In the present case report, a novel approach that combines three-dimensional guided implant planning/surgery via digital software, the use of novel atelo-collagen based xenografts/membranes with improved biocompatibility, and immediate implant placement with simultaneous vertical guided bone regeneration (GBR) is described where the patient treatment protocol was significantly reduced. Highlighted within this case report is the effective use of guided surgery via digital software, as well as the use of biomaterials that feature atelo-collagen. Since xenografts are typically devoid of all collagen and growth factor content, the recent development of natural bovine bone mineral containing atelo-collagen type I have been proposed as grafts with greater biocompatibility, thus favoring optimized bone regeneration. This article describes the protocol in detail and emphasizes the necessary requirements to optimize bone regeneration in a predictable manner.

Keywords: Bone graft; Immediate implant dentistry; Atelo-collagen; Osteogenesis; Bone regeneration

Introduction

Vertical ridge augmentation is one of the most challenging scenarios faced by a treating clinician [1-3]. Typically, a 2-stage approach is planned whereby a 9-month healing period is utilized for complete bone regeneration to take place, especially in the vertical direction [3-5]. Only thereafter are implants placed into regenerated bone and restored.

Several parameters are important to optimize bone regeneration. First, space maintenance is critical since compression towards bone is directly linked with bone resorption via a reduced vascular supply [6-8]. For these reasons and those presented later in this case report, titanium meshes, or titanium-reinforced membranes have been utilized as barriers in large bone augmentation procedures.

Much research has also focused on the choice of bone grafting materials utilized to perform bone augmentation procedures [9-11]. While each class of bone grafting materials possess their regenerative advantages and disadvantages, the use of autografts in combination with xenografts has been a favoured choice by many clinicians. While autografts are known to induce optimal bone regeneration owing to their ability to contain living progenitor cells and release of osteoinductive growth factors [12,13], they also turnover rapidly which is why clinicians have often favoured their combination with low substitution xenografts.

One of the limitations to xenografts is that the majority are completed devoid of proteins and growth factors [14]. During the sterilization process, typically xenografts undergo thermal procedures that deproteinize the graft leaving only a mineralized biomaterial. Despite this, xenografts have been one of the most widely used bone grafting materials over the past several decades [9,10,15].

Recently, the fabrication and processing of xenografts have made major advancements whereby sterilization procedures

have been optimized utilizing atelo-peptidation and lyophilization technologies that modify the immune-collagen components of collagen from the bone grafting material to non-immunogenic atelo-collagen [16,17]. Processing of xenografts utilizing these technologies has been shown to preserve the natural properties of collagen with an end-product containing roughly 30% remaining collagen type I utilizing a natural and biocompatible approach. It is therefore hypothesized that the regenerative potential of such grafts further optimizes bone regeneration.

Parallel to recent advancements made in tissue engineering of bone grafting materials, much advancement has also been pioneered in three-dimensional digital implant dentistry [18-21]. Today it is possible to plan surgeries completely virtually with surgical guides being fabricated to place implants precisely in their 3-dimensional space. Since dental implants are known osteopromotive materials, they may also be utilized as bone-promoting materials. This case reports highlights the placement of dental implants using guided digital surgery with simultaneous vertical bone augmentation of the mandibular posterior ridge. While this treatment concept saves the patient additional surgical time and morbidity by simultaneously performing the bone grafting procedure and implant placement simultaneously, we demonstrate how advancements in biomaterials as well as digital planning have optimized the clinician's ability to successfully shorten surgical treatment times for patients.

Case Report

A 64-year-old female patient presents to the University dental clinic in Parma, Italy with complaint of missing posterior teeth. Cone-beam computed topography demonstrates severe bone loss in both the horizontal and vertical directions in regions 3.4-3.6 (**Figure 1**). The bridge placed in 3.3-X-X-3.7 was reported as currently failing and there was a large radicular cyst at site 3.4. Implants are therefore planned in sites 3.4, 3.5 and 3.6 utilizing Romexis software (Planmeca, FI) and, following, Nobel clinician (Nobel Biocare) software for the surgical guide production (**Figure 2**). Notice the extent of missing bone on the buccal surface of each of these implants when digitally planned (**Figure 2**). Nevertheless, implant surgery is planned to utilize this correct prosthetically-driven position. **Figure 3** demonstrates a clinical photo of the intra-oral region 3.4-3.6. Notice the extent of bone loss observed prior to flap elevation with a knife-edge ridge. Notice the bone

loss occurring following flap elevation (**Figure 4**). Periosteal releasing incisions were performed to mobilize the flap (**Figure 5**). Three implants were placed (Nobel Active 3.5 × 13 mm - Nobel Active 4.3 × 11.5 mm - Repalce CC 4.3 × 13 mm, Nobelbiocare) in positions 3.4, 3.5 and 3.6 according to digital planning. Notice that the implants were placed crestal to the bone ridge owing to the planned vertical augmentation procedure (**Figure 6**). A 0.2 mm thick titanium mesh band was secured buccally in order to create and support an adequate regenerative space with minimal compression on the buccal bone. Notice the extent of missing bone on the buccal surface of the implants and interproximal (**Figure 7**). The defect was then filled with a mixture of autogenous bone (approximately 70%) harvested with a bone scraper (safescraper (Meta, Reggio Emilia, Italy)) [22] from the mandibular omo-lateral ramus and 30% of atelo-collagen derived xenograft (ImploBone, granule size 0.5-1 mm, Bioimplon Germany) (**Figure 8**). A bovine type I collagen membrane was then utilized to cover the entire defect and the membrane was secured in place with tacks on the buccal side and sutured on the lingual side (**Figure 9**). The flap was then double sutured closed with 4.0 sutures (**Figure 10**).

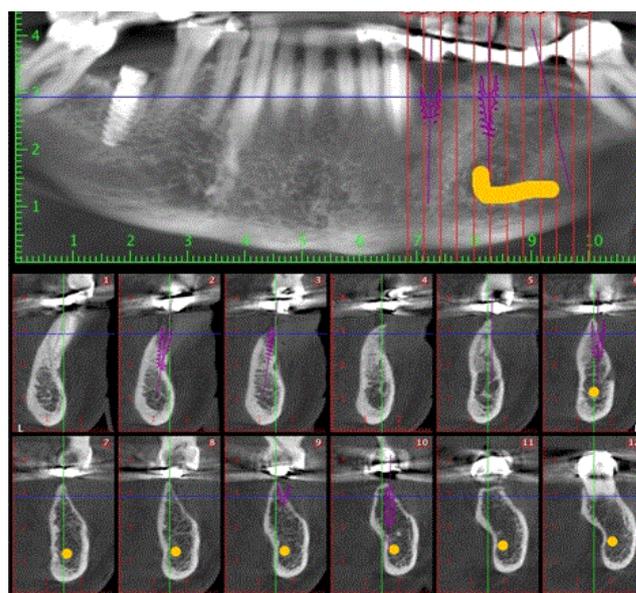


Figure 1 CBCT image demonstrating a failing bridge extending from tooth 3.3 to 3.7. Notice the extensive bone loss observed on the cross-sections CBCT images.

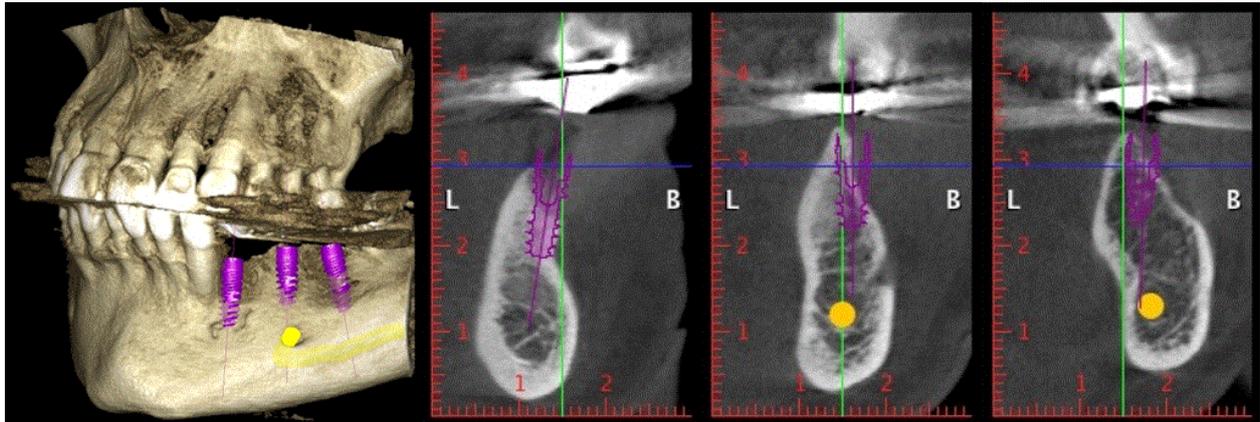


Figure 2 Implant placement planned in sites 3.4, 3.5 and 3.6. Notice that all implants are placed according to their ideal 3-dimensional prosthetic position. Each of the implants demonstrates severely lacking buccal bone when restored in the correct position.

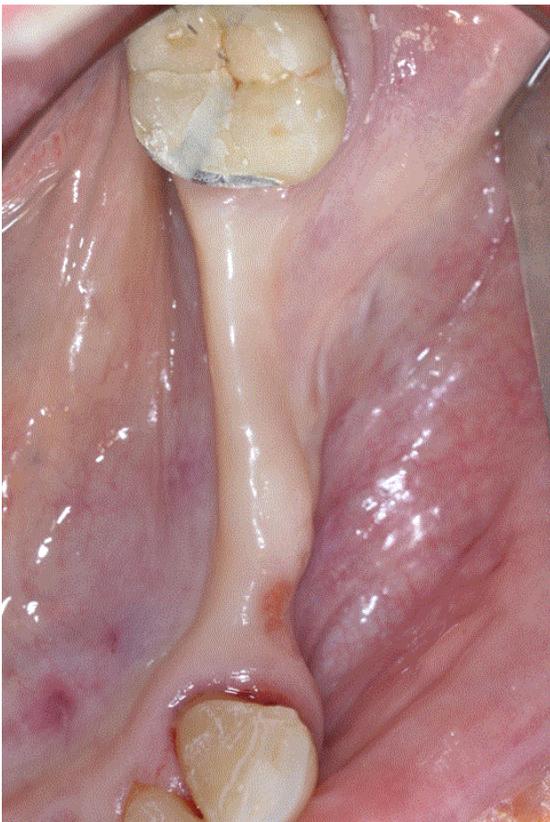


Figure 3 Clinical image of the knife-edge ridge observed between sites 3.4 and 3.6. An extensive bone augmentation procedure is planned in both the horizontal and vertical direction.

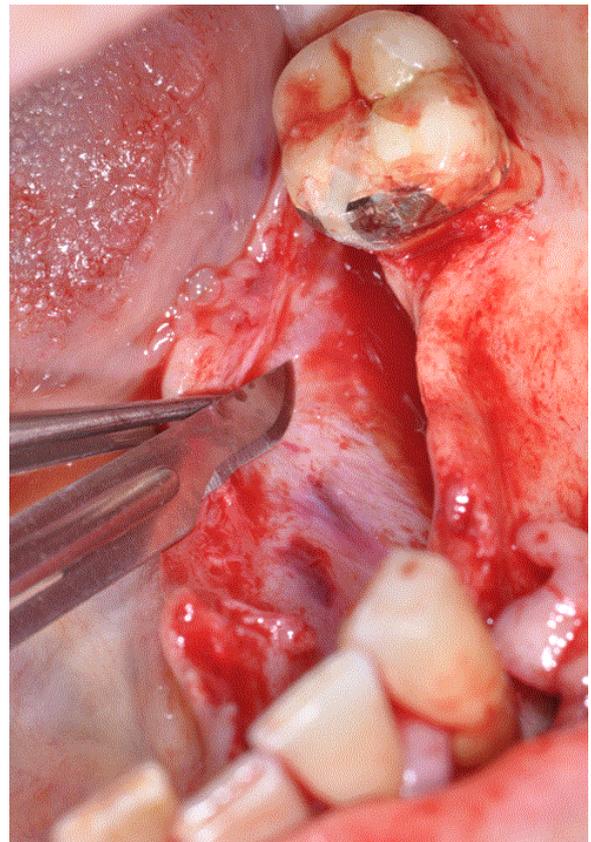


Figure 4 Notice the narrow ridge following flap elevation.

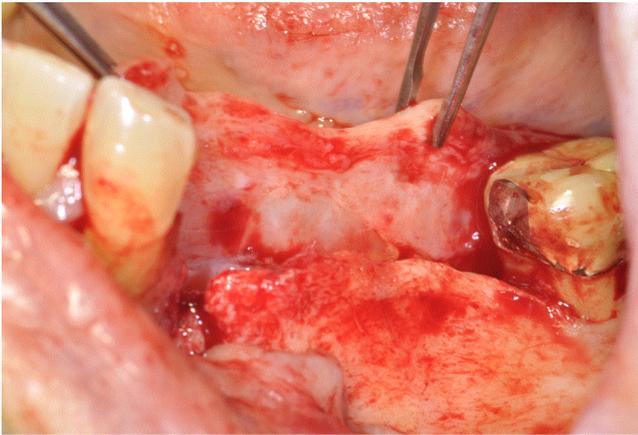


Figure 5 Obtained immobilization following releasing incisions.

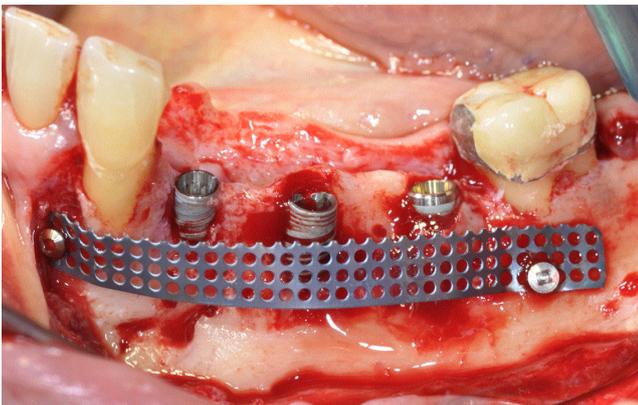


Figure 6 Implant placement in sites 3.4, 3.5 and 3.6 followed by a titanium mesh that was secured buccally with 2 screws.

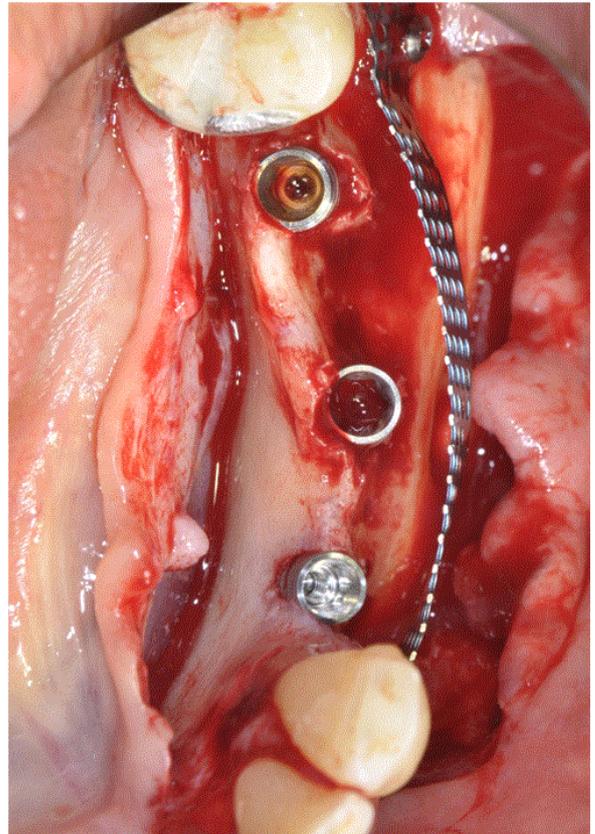


Figure 7 Notice the position of the implants relative to the amount of necessary bone regeneration required in this case.

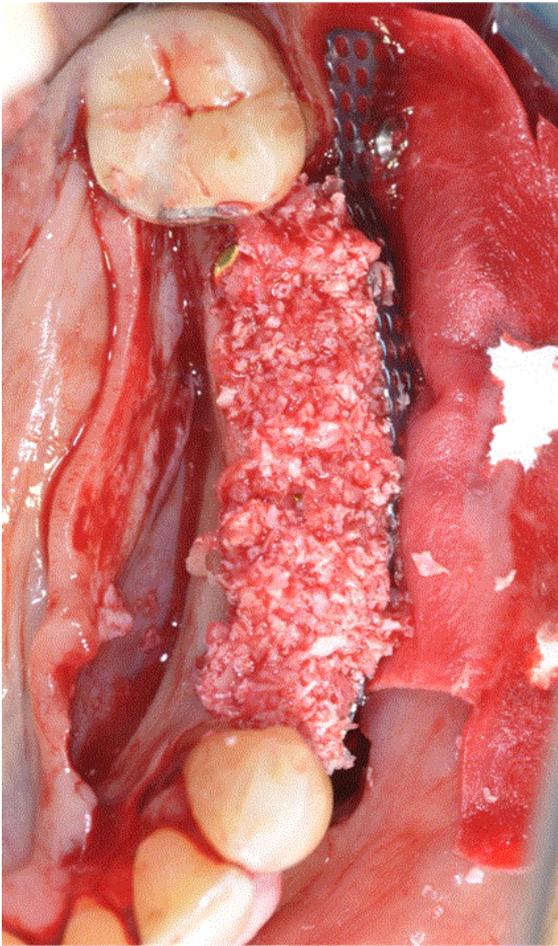


Figure 8 Defect filled with a mixture of autogenous bone (approximately 70%) harvested with a bone scraper (safe scraper) and 30% of atelo-collagen derived xenograft (ImploBone, granule size 0.2-1 mm, Bioplmon Germany).

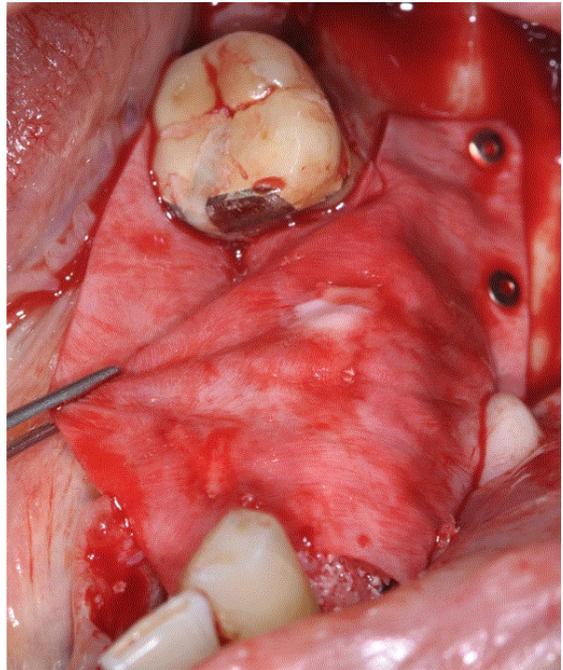


Figure 9 A bovine-derived collagen membrane was utilized to cover the titanium mesh/bone graft/implant graft and secured with tacks.

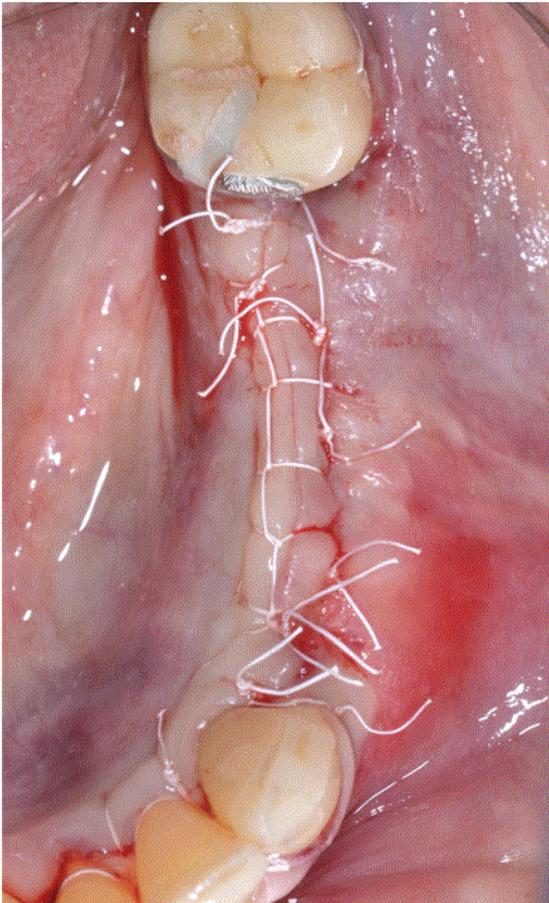


Figure 10 The graft was then closed with 4.0 sutures.

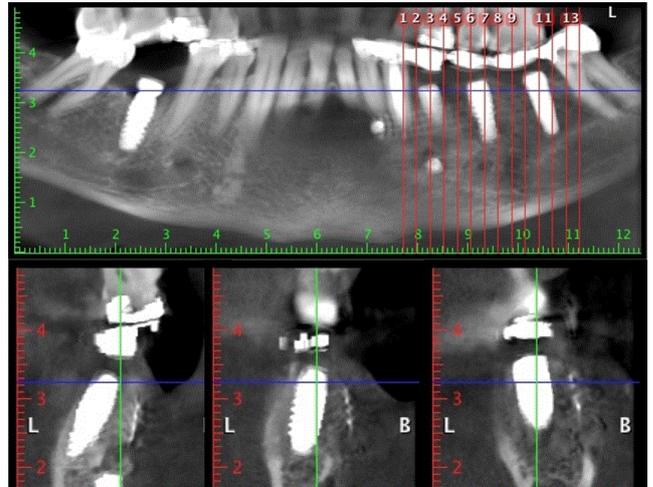


Figure 11 CBCT of the regenerated area after 7 months of healing. Notice the bone formation occurring especially on the buccal surface of all implants.

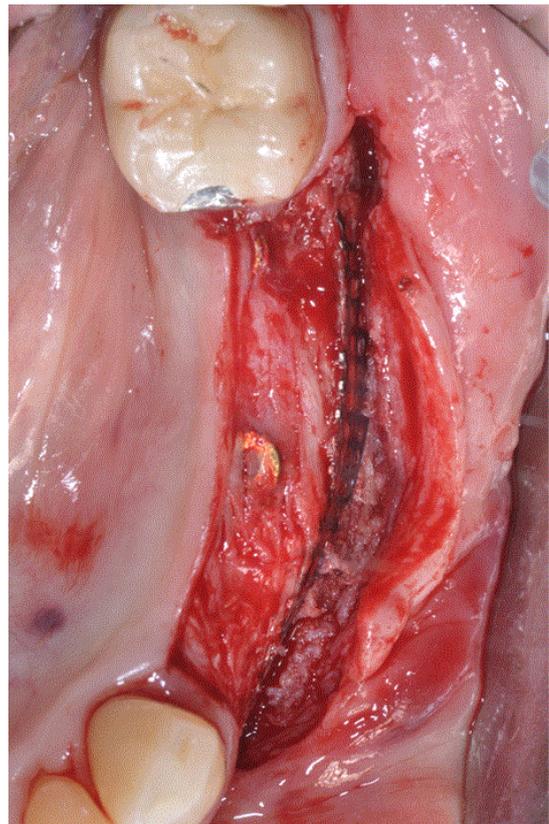


Figure 12 Partial thickness flap reveals excellent new bone formation above and around all implants.

After 7 months of healing, CBCT demonstrated adequate bone formation in both the vertical and horizontal directions (**Figure 11**). A partial thickness flap was then raised, the Ti mesh was removed and the implants were uncovered (**Figure 12**). Notice the amount of buccal bone that was formed after 7 months (**Figure 13**). A collagen matrix graft (Mucograft, Geistlich, Switzerland) was then utilized on the buccal surface to improve soft tissue thickness and healing abutments were then placed (**Figure 14**). After 15 days, sutures were removed, an impression was taken and a provisional restoration with loading was placed (**Figure 15**). Notice the excellent bone levels around the implants, viewed by X-ray (**Figure 16**). Five months later, notice the excellent soft tissue healing (**Figure 17**). A final restoration was then screwed in place (**Figures 18**). **Figure 19** demonstrates an X-ray taken 15 months post-op with excellent maintenance and bone levels around the implants.

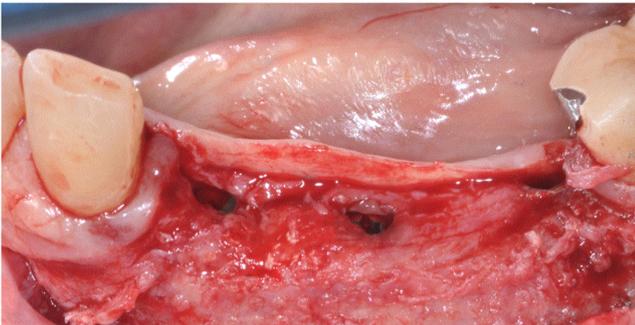


Figure 13 Notice the bone formation occurring; especially on the buccal surface.

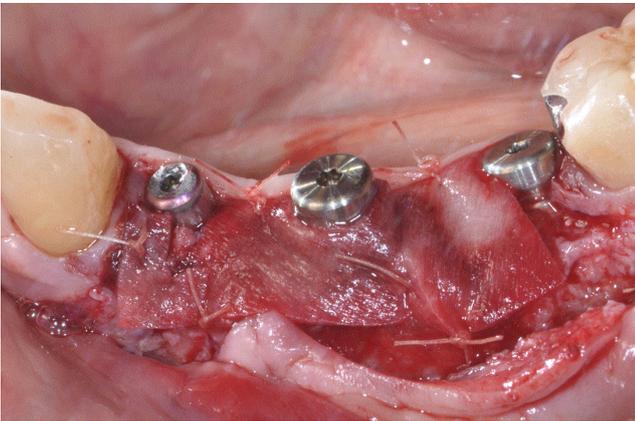


Figure 14 Mucograft utilized to improve soft tissue thickness around the implant.

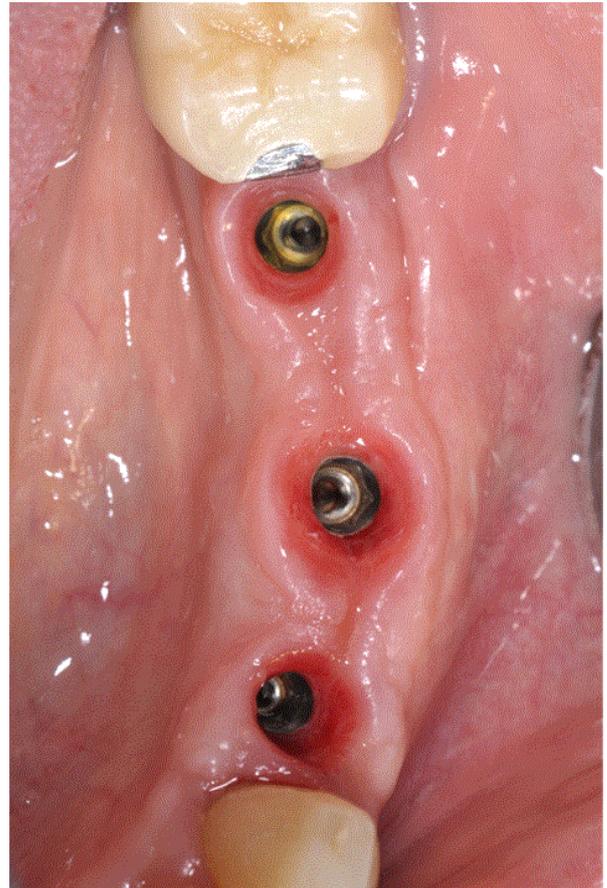


Figure 15 Fifteen days post mucograft placement, notice the soft tissue healing. A provisional restoration with load was then applied.

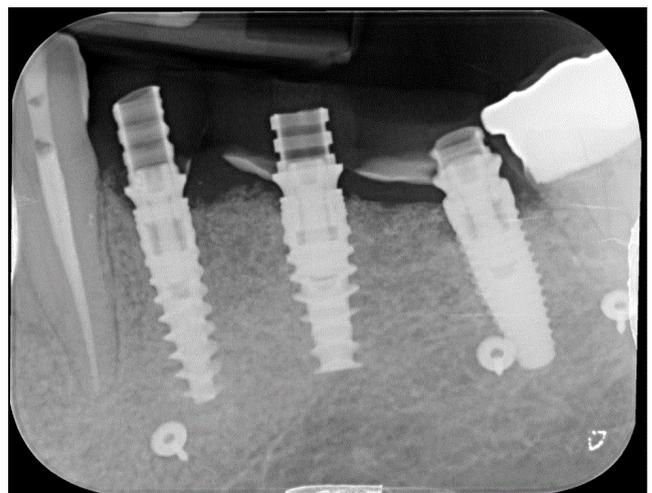


Figure 16 Notice the bone levels around the implants 7 months post initial surgery.



Figure 17 Notice the soft tissue contouring 8 months post-grafting.



Figure 18 Final zirconia restoration.

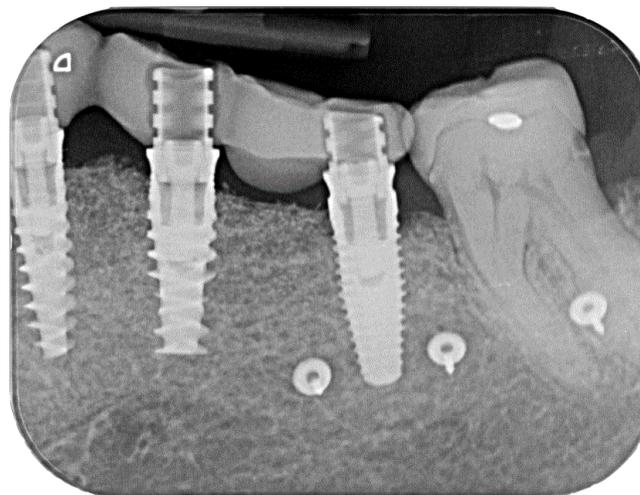


Figure 19 Final X-ray 15 months post-surgery. Notice the maintenance of excellent bone levels utilizing this treatment modality.

Discussion

The present case report demonstrated the successful use of combining a large bone augmentation procedure of a severely resorbed posterior mandible with simultaneous implant placement. Though initially the implant was placed in inadequate bone, the grafting procedure utilizing a combination of autogenous bone and xenograft mixture was able to successfully regenerate this large bone defect. It was recently demonstrated that the xenograft's incorporation of atelo-collagen offers numerous advantages when compared to xenografts devoid of collagen which include better adsorption of growth factors, as well as improved cellular attachment, proliferation and osteoblast differentiation [17].

In terms of their biomaterial characteristics, this relatively novel processing technique does not use heat (thermal) processing which has been linked with both destroying the remaining protein content from the bone graft as well as negatively impacts the natural crystalline micro-structure of hydroxyapatite. These advanced sterilization procedures for xenografts has been shown to preserve lyophilized collagen with lower humidity which favours the hydrophilicity of the bone matrix. In total, these xenografts contain roughly 2% moisture, 65-75% hydroxyapatite, 25-35% atelo-collagen content and up to 0.1% non-collagenous proteins [17]. Therefore, these combined advantages when compared to deproteinized xenografts favours their ability to further stimulate new bone formation, especially when utilized in combination with autografts – known to secrete a wide array of growth factors and cytokines [12,13].

Typically, regeneration of severely atrophic posterior mandibles is performed using a 2-stage approach [3-5]. This is owing to the difficulty in regenerating large bone defects in the posterior mandible, especially in the vertical direction. In the present study, the implants were utilized as a sort of

tenting screw with the authors knowingly aware that bone can be formed directly in opposition to the implant surface (owing to the favourable osteoconductive features of a roughened titanium surface [23,24]). In the present technique, the implants were first placed in the correct 3-dimensional position, and thereafter this bone grafting complex was utilized in combination with the implants and titanium mesh to optimize space maintenance. After only a 7-month healing period, both implant osseointegration and adequate bone regeneration were achieved in a single surgery. This favoured much shorter treatment protocols with the patient not requiring a second surgery to place implants since they were performed simultaneously.

Many new concepts were highlighted in this case report. First, the atelo-collagen bone grafting material promoted adequate bone regeneration in combination with an autograft likely owing to the better immune response to natural atelo-collagen. Furthermore, it was found that simultaneous implant placement was hypothesized to further speed graft consolidation by providing 1) space maintenance, 2) less overall defect bone volume requiring regeneration, and 3) a titanium surface that favours osteoconduction. Future long-term documented cases are nevertheless required to further validate this concept.

Conclusion

This case report describes a surgical concept/technique where concurrent guided bone regeneration and implant placement was performed simultaneously. Key features to the successful outcomes were the use of 3-dimensional implant planning/placement, as well as the use of a titanium mesh to prevent tension/compression on the regenerating bone. Lastly, novel xenograft biomaterials that incorporate atelo-collagen within the graft complex were shown to favourably promote bone regeneration, likely owing to their superior biocompatibility. Future comparative and large human studies are necessary to further validate this proposed treatment modality and validate this treatment concept.

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