

DOI: 10.21767/2471-3082.100044

Immediate Implant Dentistry and the Selection of Biomaterial to Fill the Gap: Use of Xenografts with Incorporated Atelo-Collagen

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Received date: July 09, 2018; Accepted date: July 23, 2018; Published date: August 02, 2018

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Citation: D'Avenia F, Miron R. Immediate Implant Dentistry and the Selection of Biomaterial to Fill the Gap: Use of Xenografts with Incorporated Atelo-Collagen. *Periodon Prosthodon*. 2018, Vol.4 No.2:08.

Abstract

Immediate implant dentistry has become an effective treatment modality for many clinicians to shorten treatment times. Naturally, while these implants are placed more lingually/palatally and a gap is created between the buccal bone and implant surface, an often-overlooked parameter has been the choice of biomaterial/bone graft utilized to fill this void. In the present case study, the introduction of an atelo-collagen based bone grafting material is presented with superior biocompatibility owing to the reduction in immunogenic properties of animal-based collagen. Since xenograft bone biomaterials are commonly devoid of all collagen and growth factor content (reducing their potential for causing an immune response), the recent development of a natural bovine bone mineral containing atelo-collagen type I has favoured atelo-collagen-incorporation within the bone matrix of xenografts. In the present case report, a vertical root fracture on a previously endodontically-treated right upper first premolar was extracted and an implant was immediately placed. The gap was then packed with an atelo-collagenized xenograft bone graft. A 20-month healing period is provided. This article aims to provide the clinician with a better understanding of the processing steps required to turn collagen into atelo-collagen via atelopeptidation and lyophilization technologies and results in a modification to the immune-collagen component of collagen to non-immunogenic atelo-collagen.

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

Introduction

The placement of immediate implants into fresh extraction sockets has become routine for many surgically-based clinicians aiming to speed treatment modalities. While once considered 'risky', today it is well known that immediate implant dentistry can achieve similar survival rates as those described using a delayed approach [1,2]. One topic that has been debated in recent years has been the choice of bone grafting material utilized to fill the gap created between the remaining buccal wall and the implant surface. Many studies (both pre-clinical and clinical with/without implants) have found marked dimensional alterations occurring post extraction if no biomaterial is utilized [3-5].

A few concepts have been proposed to influence dimensional change post-extraction. First the presence of a thin buccal wall, often characterized as less than 1 mm, is more prone to resorption [3,4,6,7]. This remains prominent especially in the esthetic zone where the buccal plate is often thinner than 1 mm [6,7]. If a proper selection criterion is not enforced, there is an increased risk of implant exposure to the midfacial implant surface from mucosal recession, which in certain clinical studies has been reported to occur as high as 40% of the time in immediate implant dentistry cases [8-10]. Plausible factors that may be responsible for these unsatisfactory esthetic outcomes include 1) facial bone wall thickness, 2) tissue biotype, 3) implant type, 4) implant size and 5) implant positioning [11,12].

Today it is well known that a proper surgical technique is of primary importance for the successful placement of immediate implants. Nevertheless, also essential is the choice of biomaterial utilized to minimize dimensional changes that occur post-extraction and to maximize bone formation resulting in more favourable clinical and esthetic results. Much research to date has focused on the bone-inducing ability of certain classes of bone grafting materials [13,14]. Nevertheless, very little investigation thus far has investigated

the possibility to further improve/optimize the regenerative potential of each of these classes of biomaterials.

Xenografts are a class of bone grafting material highly utilized in dentistry owing to their low substitution rate/properties. The most commonly utilized xenografts are completely devoid of proteins with growth factors removed during thermal processing of the grafting material for sterilization purposes [14]. The end-result is a deproteinized graft that maintains its mineralized properties. Nevertheless, xenografts are one of the most widely used biomaterials in dentistry [15-17].

Recently, the fabrication and processing of xenografts have made major advancements. Sterilization procedures have been modified utilizing atelopeptidation and lyophilization technologies that transform the immune-collagen components of collagen to non-immunogenic atelo-collagen [18,19]. It has been found that processing of xenografts utilizing these technologies preserves the natural properties of collagen with an end-product containing roughly 30% collagen type I.

It has therefore been hypothesized that the regenerative potential of these atelo-collagen-derived bone grafts may potentially further promote new bone formation. In the present case report, we demonstrate how the use of atelo-collagen derived bone grafts and a barrier membrane were utilized in an immediate implant case to fill the implant gap. We demonstrate a case follow up time of 20 months with minimal dimensional change or bone loss that occurred over this 20-month period.

Case Report

A 48-year-old female patient presents to the D'Avenia Dental Clinic in Parma, Italy with complaint of pain on an upper right first pre-molar. **Figure 1** demonstrates the clinical presentation of the case. A subsequent X-ray and clinical investigation revealed a vertical root fracture on a previously endodontically-treated right upper first premolar (Tooth 1.4, **Figure 2**). The tooth was deemed non-restorable owing to the extent of the fracture. The patient was presented several options including replacement with a dental implant. Following discussion, the patient elected to have an immediate implant placed with immediate temporization. The case demonstrated adequate buccal bone thickness (>1 mm) with a thick tissue biotype.



Figure 1 Clinical photo demonstrating tooth 1.4.



Figure 2 Patient presents with a vertical fracture on a previously treated endodontic tooth 1.4.

Figure 3 depicts the digital planning of the implant case. As can be observed, the implant was planned more palatally than the original tooth in order to maintain the buccal bone and create a space to pack a biomaterial into the gap. The gap was filled with a xenograft that is derived from a bovine source that integrates atelo-collagen within its matrix (ImploBone particle sizes ranging from 0.5 to 1 mm, Bioimplon, Germany, **Figure 4**). **Figure 5** illustrates a series of clinical images depicting the clinical steps utilized in this case report as follows: 1) atraumatic tooth extraction, 2) immediate implant placement with a 4.3 x 13 mm. MIS V3 implant (M.I.S. Savion, Israel), 3) packing of the gap with an atelo-collagenized bone xenograft, 4) temporization of the crown, and 5) final preparation of the temporary crown. **Figures 6** and **7** demonstrate the vertical root fracture from both the mesial and distal aspects respectively. **Figure 8** illustrates the baseline photo of the final provisional restoration on the day of tooth extraction/immediate implant placement. The height of the buccal cusp was reduced, and the occlusion was slightly more lingualized redistribute and minimizes forces was considered.

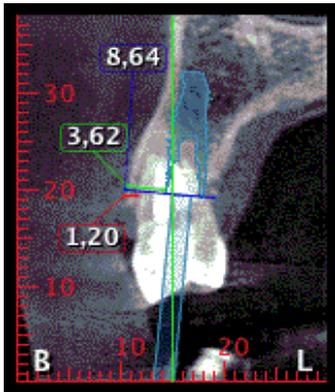


Figure 3 Digital implant planning with ideal implant positioning. The labial surface of the buccal bone demonstrated a 1.22 mm thickness – adequate for immediate implant placement.



Figure 4 Clinical appearance of atelo-collagenized bone grafting xenograft (ImploBone, Bioimplon).



Figure 5 Case demonstration. Initial tooth that was atraumatically extracted. Implant placement. The gap was then packed with ImploBone (0.2-1mm, Bioimplon). A provisional restoration was then fabricated and finalized.



Figure 6 Mesial root fracture – notice the fracture half way down the tooth root.



Figure 7 Distal root fracture – notice the fracture that extends lingually.



Figure 8 Baseline photo of the provisional restoration immediately following immediate implant placement.

Figure 9 demonstrates the clinical and X-ray photos at 3 months. Notice the excellent soft tissue adaptation and the bone levels around the implant. **Figure 10** illustrates the clinical and X-ray photos at 4 months when the final impression was taken. **Figure 11** demonstrates the final restoration restored at 5 months. Notice the excellent soft tissue adaptation (**Figure 12**). **Figures 13 and 14** demonstrate the long-term stability of this case utilizing these biomaterials. First, notice the excellent soft tissue maintenance over a 20-month period (**Figure 13**). Second, notice the implant bone shoulders on both the mesial and distal aspects of the implant (**Figure 14**). **Figure 15** demonstrates the before and after width of the tooth and implant. Originally, an 8.64 mm distance was measured. After 20 months, the buccal-palatal width of the implant remained stable at 8.41 mm. Furthermore, 3.54 mm of bone remains present on the buccal surface of the implant, wide enough to favor bone maintenance over time (**Figure 15**).

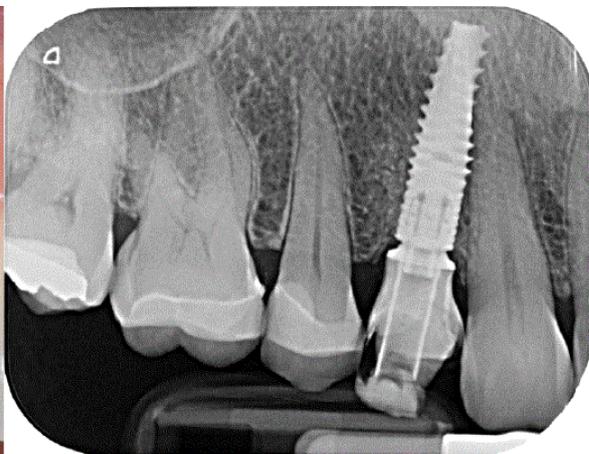


Figure 9 Clinical photograph and X-ray at 3 months post-op. Notice the excellent soft tissue wound healing.

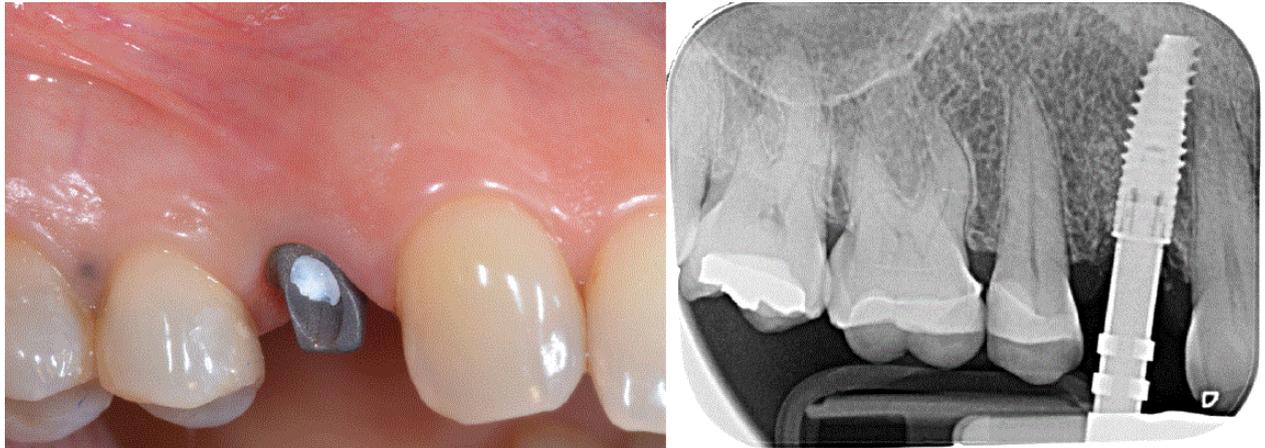


Figure 10 Final impression at 4 months post-op. Once again notice the excellent soft tissue healing and maintenance of papilla on both the mesial and distal sites of the implant.



Figure 11 Final restoration at 5 months post-op.



Figure 12 Final restoration at 5 months post-op.



Figure 13 Final restoration at 20 months post-op.



Figure 14 Final X-ray at 20 months post-op. Notice the excellent long-term maintenance of bone around the implant and inter-proximally.

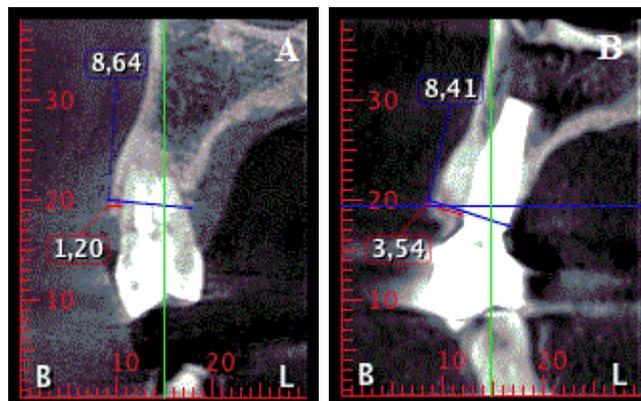


Figure 15 Pre and 20-month post-op CBCT images. Notice the excellent maintenance of the bone dimension over time. Originally measured at 8.64 mm in width. 20 months later the dimension remains at 8.41 mm. Furthermore, while 1.2 mm of buccal bone was present pre-op, the finding from 20 months post-op revealed a 3.54 buccal bone surface.

Discussion

The present case report demonstrates the successful use of an immediate implant that was placed slightly palatally with the 'gap' being filled with an atelo-collagen derived xenograft. As the year's progress, there has been increasing interest to shorten treatment times by placing implants immediately into fresh sockets. While clinically this requires a more advanced surgical skillset, the desired end-goal of immediate implant placement is to better optimize gingival contour yet maintain the dimensional width prior to tooth loss [20].

The clinical question/concern that is often expressed is the alterations in hard tissues that occur post extraction [5,21]. When the tooth is extracted, as is the periodontal ligament that contains a bundle of blood vessels typically responsible for supply blood flow to the surrounding bone. This has been particularly prominent when the buccal bone plate is less than 1 mm in thickness [6,7]. In present case report, immediate implant placement was considered based on two primary indications: 1) the remaining buccal plate was greater than 1 mm in size and 2) the patient presented with a thick biotype.

Today it is well known that the positioning of implants during placement, should be more palatally. During immediate implant placement, this creates the so called buccal 'gap' between the exposed implant surface and the buccal bone. This gap may then be filled with a variety of biomaterials capable of inducing bone formation. In the present study, we hypothesized that the use of a xenograft containing atelo-collagen would better serve the function of promoting more ideal bone regeneration. It was recently shown that the inclusion of atelo-collagen within the xenograft offers numerous advantages when compared to xenografts devoid of collagen [19]. Atelo-collagen has been shown to favour better

growth factor adsorption, improve cellular attachment, promote faster cell proliferation and leads to greater osteoblast differentiation [19].

The processing technology was described in a recent study. During the processing of typically xenografts, heat (thermal) sterilization is typically utilized for sterilization purposes however the increasing temperatures have also been associated with both destroying the remaining protein content from the bone graft as well as negatively impacting the natural crystalline micro-structure of hydroxyapatite. The advanced sterilization procedures found in atelo-collagen-derived xenografts preserves the lyophilized collagen which also favours the hydrophilicity of the bone graft. In total, it has been shown that these grafts contain roughly 2% moisture, 65-75% hydroxyapatite, 25-35% atelo-collagen and up to 0.1% non-collagenous proteins [19]. We therefore were interested to utilize this technology in an immediate implant grafting case. To the best of both the authors knowledge, this is the first case report investigating the use of atelo-collagen based xenografts for such indications.

While the surgical procedure was as planned, most notably, the authors report the excellent soft tissue healing. It may therefore be reported that the superior biocompatibility of atelo-collagen over collagen is thought to have contributed to the final results by minimizing tissue inflammation and speed wound healing. Second, the buccal-palatal distance in the present case report was well maintained even at 20 months post-op. While this case will certainly be followed over time to further document changes at 5+ years, these initial healing results are very encouraging. Further histological analysis is also of interest to further determine the quality and quantity of bone formation taking place around these grafting particles.

Conclusion

This case report describes a surgical approach whereby implant placement was significantly shortened owing to the ability to immediately place the implant with immediate temporization. A novel xenograft bone graft that incorporated atelo-collagen within the graft complex was utilized in this study and was shown to favourably promote bone formation, likely owing to the superior biocompatibility of atelo-collagen. Future comparative studies and histological studies are now necessary to further validate this novel biomaterial.

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