

Guided Bone Regeneration (GBR) Using Nano-Crystalline Calcium Sulfate Bone Graft in Extraction Socket: A Case Report

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Introduction: The use of bone graft to replace the lost bone in extraction sockets is commonplace today. They help in maintaining the height and width of the bone for eventual placement of dental implants.

Case Presentation: A 41-year-old female patient presented to the private clinic with a hopeless tooth number 31. Atraumatic extraction was performed. The socket was cleaned. Infected, inflamed tissue as well as remnants of periodontal ligament was removed. The site was thoroughly irrigated and de-corticated. Particles of nanocrystalline calcium sulfate (nCS) were mixed with saline to form the putty. nCS putty was then lightly condensed in the extraction socket with a plastic instrument and a plugger. The site was closed with a barrier membrane. Radiograph was taken before and after the surgery. Patient was followed regularly. Four months after grafting the socket, two dental implants were placed in the healed socket. A small core of the bone from the grafted socket was obtained before implant placement and was analyzed histologically as well as histomorphometrically. Socket healing was uneventful. Histological analysis demonstrated robust bone regeneration in the socket, histomorphometrical analysis showed 52% bone and 48% soft tissue. 100% of the bone was vital. Implants were restored four months after placement.

Conclusion: This case demonstrates the effective use of nCS for guided bone regeneration in molar extraction socket.

BACKGROUND

Vital bone volume, quantity as well as quality, is a key factor when considering the placement of dental implants. Preservation of alveolar dimensions after tooth extraction is crucial to achieve optimal esthetic and functional prosthodontic results as well as to maintain adequate bone volume for placement and stabilization of implants¹. Site preservation through socket grafting helps to optimize bony fill within the extraction socket, thereby maintaining vertical bone height and helping to stabilize the marginal soft tissues at the site. This generally results in a healed site, which lends itself well to implant placement with a high degree of predictability as well as improved soft tissue contour². In an attempt to preserve the alveolar bone, numerous biocompatible regenerative materials have been used immediately following tooth extraction to fill the socket³.

Alloplasts have gained considerable attention; calcium sulfate has been used for 110 years for bone grafting purposes⁴. These serve as excellent alternatives to autogenous grafts that are faced with difficulties such as procurement and the need for a second surgical site (autograft). Calcium sulfate, is a biocompatible, osteoconductive and angiogenic bone graft that completely resorbs over a period of time⁵. Its degradation leaves behind a calcium phosphate scaffold that allows for migration and proliferation of osteoblasts. Its degradation creates an acidic environment that allows growth factors to be released from the surrounding bone⁶. Calcium sulfate is the only bone graft that is also effectively used as a barrier membrane to prevent

ingrowth of soft tissues. Studies by Payne et al have shown that calcium sulfate has barrier properties that are superior to poly l lactic acid (PLLA) and expanded polytetrafluoro ethylene (ePTFE) barriers⁷. Strocchi et al observed that significantly more blood vessels grew in defects grafted with calcium sulfate compared to those grafted with autograft leading some researchers to believe it has angiogenic potential⁵.

A randomized controlled study conducted at Indiana University has shown that calcium sulfate and allograft bone elicit similar bone response when used to treat extraction sockets of single rooted teeth⁸. Another study conducted by Kutkut et al has demonstrated that it can be highly effective when used in combination with platelet-rich plasma (PRP)⁹. The only disadvantage associated with calcium sulfate is its fast degradation¹⁰. To overcome its disadvantage of rapid degradation, a nano-crystalline form of calcium sulfate (nCS)⁸ was developed. nCS undergoes sustained degradation compared to traditional medical grade calcium sulfate. The aim of this case report was to study the socket preservation using nCS bone graft.

CLINICAL PRESENTATION & CASE MANAGEMENT

A 41 year old female underwent an extraction of tooth number 31. The patient was otherwise healthy and a non-smoker. She did not have a history of hypertension or diabetes. The surgery was performed at a private clinic in Israel in May 2010.

Following administration of local anesthesia, the extraction was carried out atraumatically. The socket was thoroughly debrided to remove all remnants of the periodontal ligament as well as all infected and inflamed tissues. The extraction socket was then decorticated with a ½ round bur and copious irrigation was done to enhance the vascular supply (Fig. 1). nCS was mixed with saline to form the moldable putty, which was then grafted into the defect (Fig.2). The graft material was lightly packed into the extraction socket in an incremental fashion with a flat plastic instrument and plugger that was used to lightly condense the particulate graft to the top of the bony socket walls. The graft material was placed into the socket up to the level of the surrounding socket walls. A guided tissue regenerative (GTR) membrane¹¹ made up of porcine pericardium was appropriately trimmed and then placed and adapted over the extraction socket (Fig. 3). The site was then covered with the repositioned gingival tissues that were sutured using resorbable interrupted mattress sutures (Fig. 4). Peri-apical radiograph was taken at this time (Fig. 5). Post-operative care comprised of 0.12% chlorhexidine rinses twice daily for 4 weeks, systemic antibiotics (amoxicillin 500 mg every 8 hourly) for 1 week, analgesic medication (Ibuprofen 400 mg every 8 hours) for 3 days. Sutures were removed after 14 days. The site was allowed to heal and any adverse event or complication observed was noted during the course of the treatment.

Four months after grafting the extraction socket, two dental implants were placed to restore the site. Clinical evaluation was performed before placing dental implants. A panoramic radiograph of the site was taken after placing the implants. At the time of implant placement, a small core of the bone was removed and analyzed histologically. Prosthetic restoration was performed four months after the implants were placed. Clinical, radiographic and histological analysis was used to determine the outcome of the case.

Histological Protocol

Retrieved bone core was fixed in 10% phosphate buffered formalin and then dehydrated in increasing gradients of alcohol concentrations. The core was infiltrated and embedded in methyl methacrylate (MMA) and then sectioned. The cut section was glued onto glass slides, ground down and polished to a thickness of approximately 100 μ m. Stevenel's Blue and Van Giesons Picro-Fuchsin stain were used to stain the slide. The slide was imaged using a slide scanner[†]. Histomorphometrical analysis was performed using the Leica Qwin software[#].

CLINICAL OUTCOMES

Four months following grafting, the extraction site healed with no adverse event. Clinical evaluation revealed fully keratinized soft tissue covering the underlying bone (Fig. 6). Trans-gingival probing of the grafted area revealed the presence of underlying solid bone. Radiographic examination showed bone density of the healing site to be comparable to the surrounding bone (Fig. 7). In view of the clinical and radiological assessment of bone quantity and quality, two implants were placed at this time point (Fig. 8). Primary stability was achieved with alveolar bone height reaching the first thread of the implant. The patient was regularly monitored clinically and radiographically post surgery. Prosthetic rehabilitation was completed four months following implant placement (Fig. 9 a and b).

The entire cross-section of the histological slide was studied. It demonstrated robust new bone formation in the extraction socket. Osteoblasts, blood vessels, bone marrow and osteoid tissue were noted (Fig. 10 a and b). Fifty-two (52)% of the area was covered with bone, where as forty-eight (48)% was soft tissue. One hundred (100)% of the bone was vital bone. Presence of residual graft material was not noted.

A panoramic radiograph obtained 18 months after the surgery demonstrated stable implants and prosthesis (Fig 11).

DISCUSSION

Healing of extraction sockets is usually associated with the loss of residual ridge height and width. If bone resorption is significant, then placement of an implant becomes challenging. Post extraction maintenance of the alveolar ridge allows placement of an implant that satisfies esthetic and functional criteria. The socket takes about 4-6 months to be filled with lamellar bone and even then does not attain the desired height and width. The degree of ridge resorption greatly increases with the time elapsed since tooth extraction, with the greatest resorption occurring in the immediate post-extraction period¹¹. It has been proposed that this bone resorption may result from anatomic, prosthetic, metabolic, and functional factors. Misch et al speculated that the loss of crestal bone height and labial plate after tooth extraction is due in part to the constriction of the blood clot within the alveolus and the thin labial cortical plates remodeling in response to inadequate blood supply after the extraction¹². The sequelae of tooth extraction may result in 40% to 60% loss of bone height and width within 2 to 3 years¹³.

GBR techniques and the use of bone replacement grafts have both been shown to enhance socket healing and to potentially modify the resorption process. Studies have shown the beneficial effects of the use of regenerative materials in augmenting the alveolus following extractions as compared to the socket healing alone³. Bone augmentation techniques using calcium sulfate have demonstrated potential in surgical therapy. It has been found to be biocompatible, biodegradable, osteoconductive, safe and non-toxic. It also exhibits angiogenic,

hemostatic and barrier membrane properties. Numerous studies have cited the advantages of the use of calcium sulfate bone grafts in various osseous defects and shown them to exhibit superior results over other alloplasts and comparable results to those of autografts^{14,15}. The unique microscopic structure of the nCS graft enabled it to undergo controlled degradation over a period of 16 weeks as compared to 4 to 6 weeks for traditional calcium sulfate. Because of the rapid degradation of traditional calcium sulfate, many dentists use it only in combination with other bone grafts. The controlled degradation of nCS enables them to use it as a bone graft. As it undergoes degradation, it leaves behind a calcium phosphate trellis. Osteoblasts attach to it and deposit bone along it. This phenomenon occurs over a period of 3-4 months in cases of bone defects grafted with nCS compared to 4-6 weeks for defects grafted with traditional calcium sulfate. Additionally, other mechanisms discussed in the Introduction occur over a longer duration as well. As a result, nCS facilitates more effective bone formation compared to traditional calcium sulfate. The results of this case have been very promising in achieving a sound bone quality and a clinically healthy overlying gingival tissue with the use of nCS in the extraction socket.

Xenografts are another alternative for GBR. Artzi et al investigated the quality of newly formed bone and the contact between graft and bone when bovine bone (250-1000 μ particle size) was grafted in single-rooted maxillary extraction sockets. Histological analysis of cores from grafted sites was performed 9 months following socket grafting. Analysis indicated that, for the most part, bone was in direct contact with the graft. However, bovine bone was still present after 9 months¹⁶. Similar results were observed when Rasperini et al¹⁷ used a mixture of bovine bone and collagen for grafting the extraction sockets. Horowitz et al studied bone regeneration in maxillary and mandibular posterior extraction sockets after grafting them with β tricalcium phosphate (β -TCP) and calcium sulfate (CS). Resorbable barriers were used to cover the graft material. The maxillary site was grafted with β -TCP and CS/methylcellulose graft binder rendering 32% vital bone with 8% graft remnant. The mandibular site grafted with β -TCP mixed with the patient's blood rendered 51% vital bone with 1% graft remnant¹⁸. The proposed therapy for enhancing extraction sockets led to a 100% success rate in implant placement and loading.

A study by Crespi et al¹⁹ investigated the radiographic and histomorphometric results obtained three months after grafting posterior extraction sockets with either CS or magnesium-enriched hydroxyapatite (MHA). Mean vital bone analysis showed a significant difference ($p < 0.05$) between test sites treated with CS and the ones treated with MHA (45% ± 7 and 40% ± 3 , respectively). Both test groups had significantly more vital bone than the control group (33% ± 6 vital bone) where the sockets were left unfilled. Their analysis revealed a 14% ± 3.4 residual graft material for the CS group and 20% ± 3 residual graft for MHA group.

In our case study, we observed 52% bone formation, 100% of which was vital bone. Our results are in accordance with other studies, emphasizing that using granular materials with a controlled degradation promotes bone regeneration.

Use of GTR membranes have been shown to result in a considerably less amount of ridge resorption as compared to sockets allowed to heal naturally. The GTR membrane that was used was a Jason collagen fleece that allows epithelial migration in a short period of time. It is biocompatible, exhibits multidirectional strength and tear resistance, easy to use, and possesses adequate cell occlusiveness to promote osteoblasts and periodontal ligament cell proliferation while excluding gingival cell invasion. The use of an occlusive membrane eliminates the problem of particle migration while simultaneously preventing epithelial and soft tissue

migration into the socket. It also prevents external ridge resorption in the early healing period²⁰. Hence, socket preservation procedures at the time of tooth extraction improve the prognosis related to maintenance of the width and height of the remaining bone.

CONCLUSION

The use of nCS in conjunction with a guided tissue regeneration membrane indicates a good treatment option for ridge preservation following extractions.

SUMMARY TABLE

Why is this case new information?

This is the first case that studied and discusses the use of nanotechnology based material nCS for the treatment of extraction socket.

What are the keys to successful management of these cases?

Appropriate packing of the extraction socket followed by closure of the defect to prevent patient from chewing on the grafted site.

What are the primary limitations to success in these cases?

This is single case report. More extensive studies would be needed to confirm our results.

CONFLICT OF INTEREST

Dr. Mamidwar works as General Manager at Orthogen, LLC.

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Figure 1

Extraction socket formed as a result of removal of tooth number 31.

Figure 2

NanoGen putty grafted in the extraction socket.

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Figure 3

GTR membrane placed over the grafted socket.

Figure 4

The site is closed with interrupted mattress sutures.

Figure 5

Peri-apical radiograph of grafted socket.

Figure 6

Clinical evaluation of the site 4 month after grafting.

Figure 7

Panaromic radiograph 4 months after grafting the site.

Figure 8

Implants placed in the socket.

Figure 9

Abutments were placed 4 months after implant placement (a: radiograph, b: digital picture).

Figure 10 (and b)

Histological examination of the bone core obtained at the time of implant placement. a: Bar represents 400 microns. b: Bar represents 200 microns and demonstrates structures like osteoid bone and blood vessels.

Figure 11

Panaromic radiograph obtained after 18 months.

§ NanoGen, Orthogen, LLC, Springfield, NJ, 07081

|| Jason Membrane, Botiss Dental, gmbh, Berlin, Germany

¶ ScanScope GL, Aperio, Vista, CA, 92081

Leica Microsystems, Inc. Buffalo Grove, IL, 60089



Figure 1: Extraction socket formed as a result of removal of tooth number 31.

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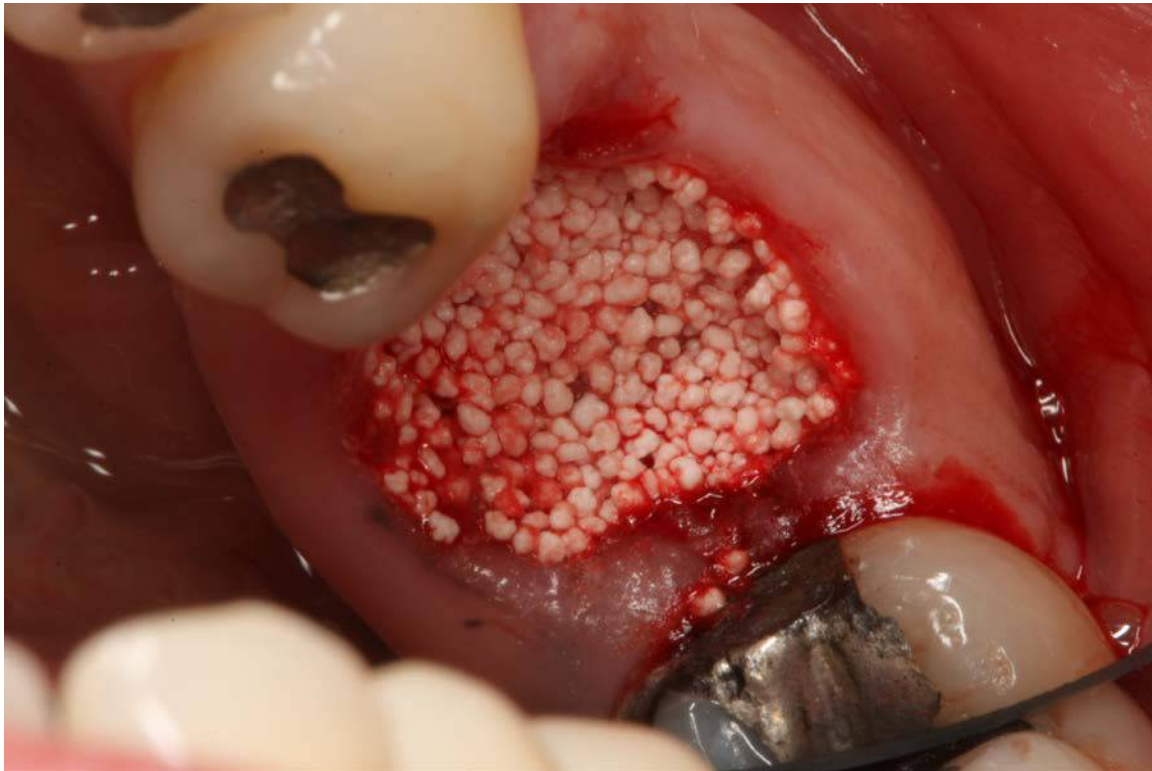


Figure 2: NanoGen putty grafted in the extraction socket.

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Figure 3: GTR membrane placed over the grafted socket

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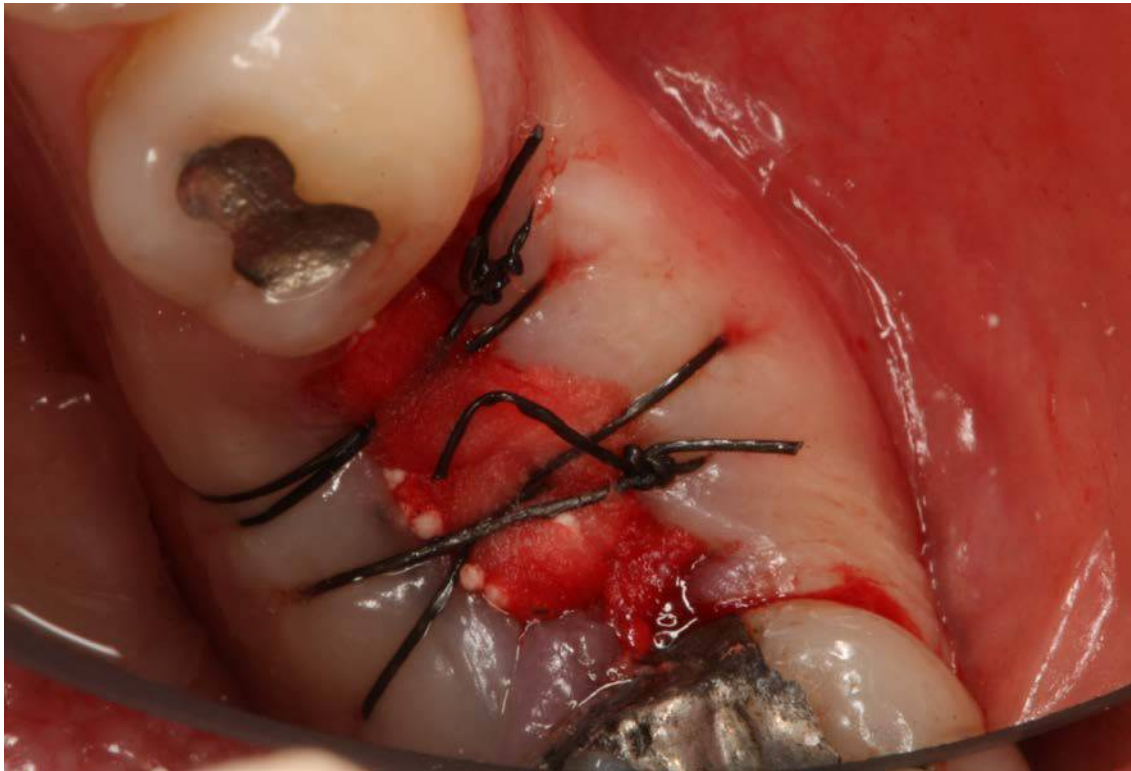


Figure 4: The site is closed with interrupted mattress sutures

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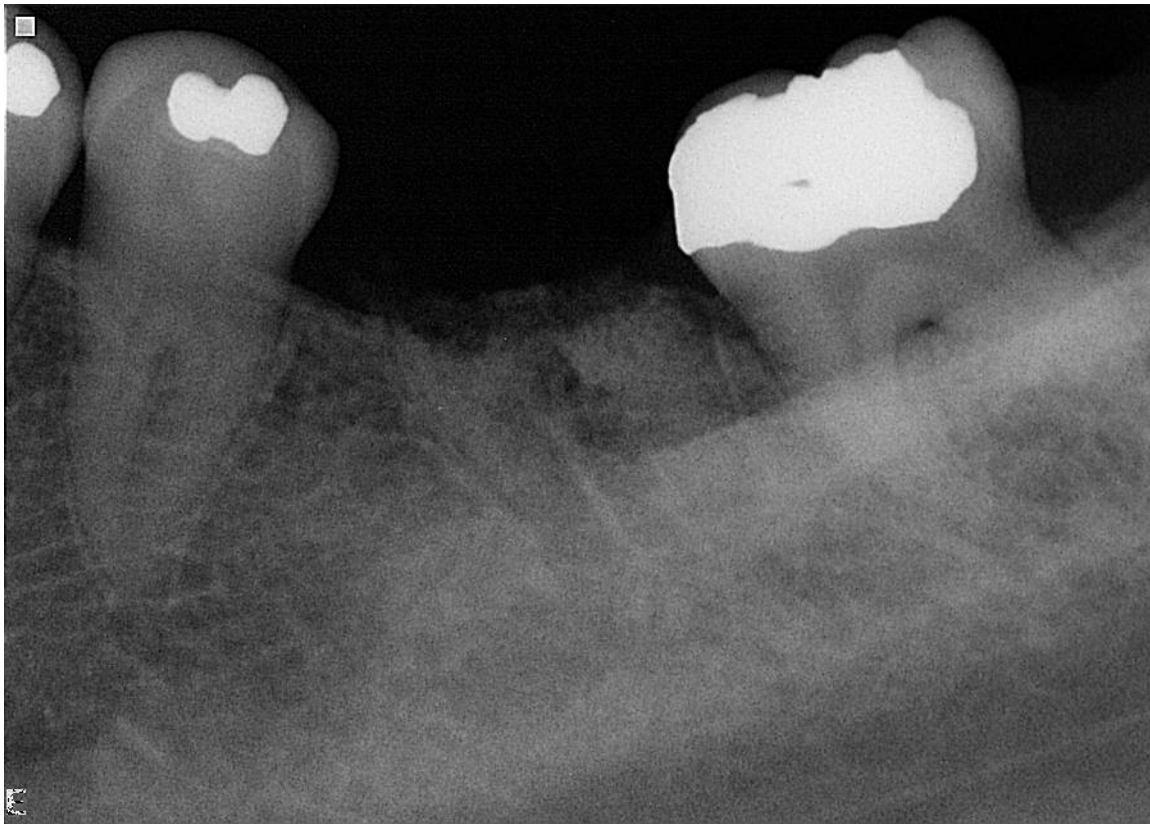


Figure 5: Peri-apical radiograph of grafted socket.

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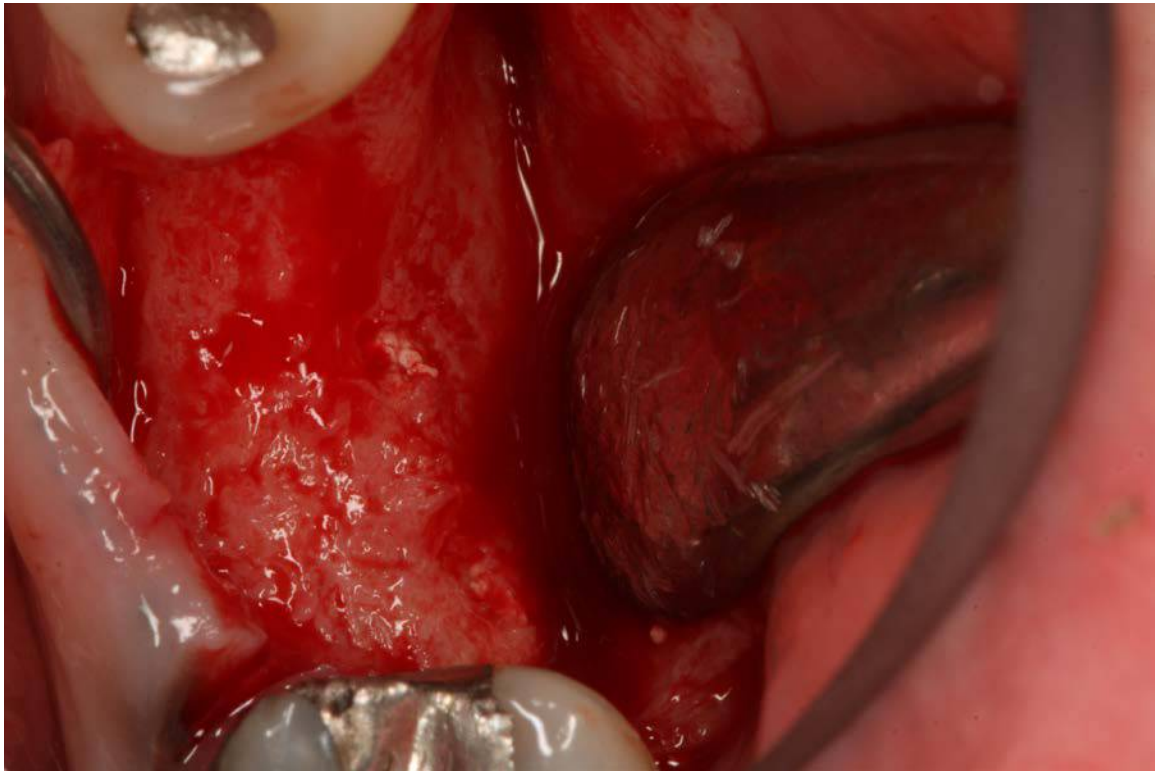


Figure 6: Clinical evaluation of the site 4 month after grafting.

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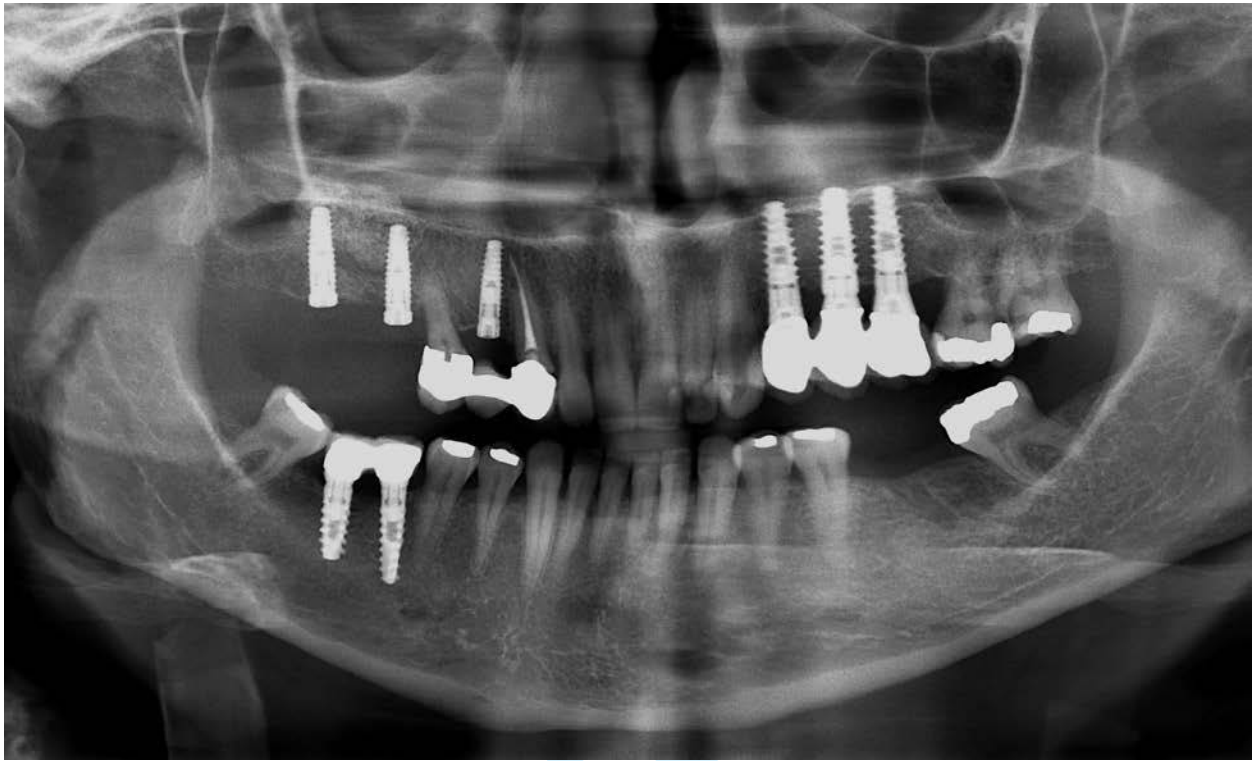


Figure 7: Panoramic radiograph 4 months after grafting the site.

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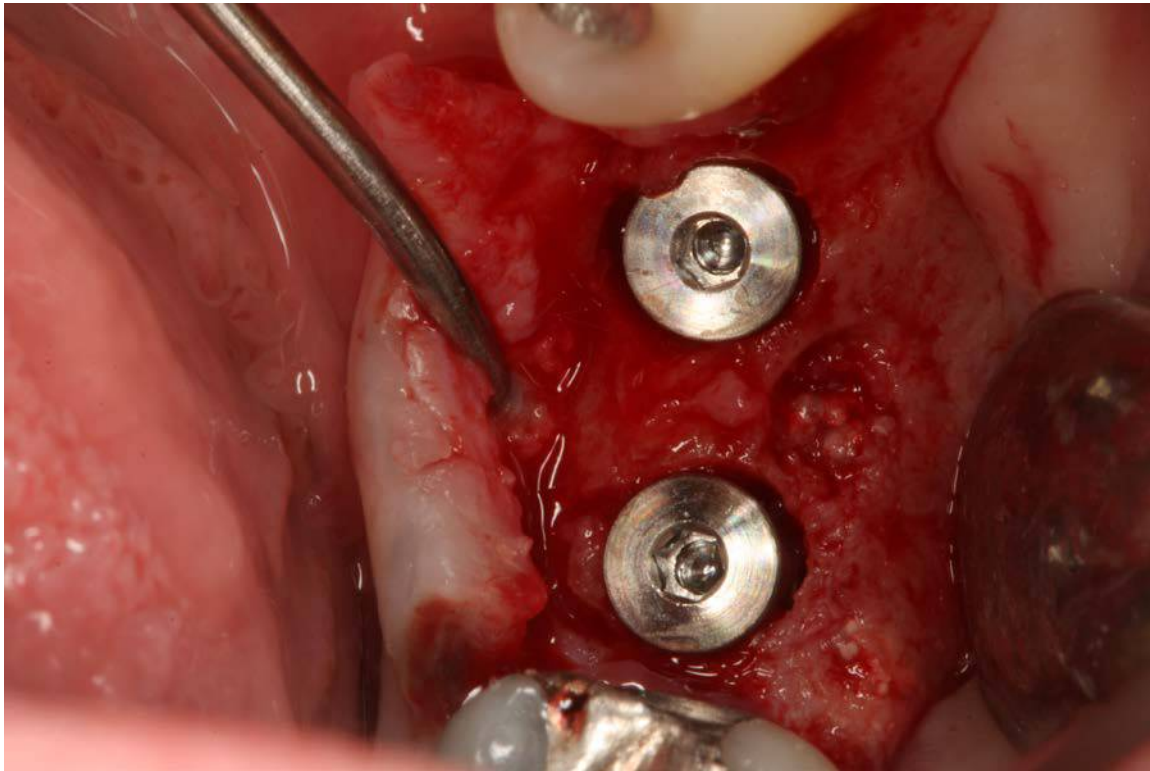
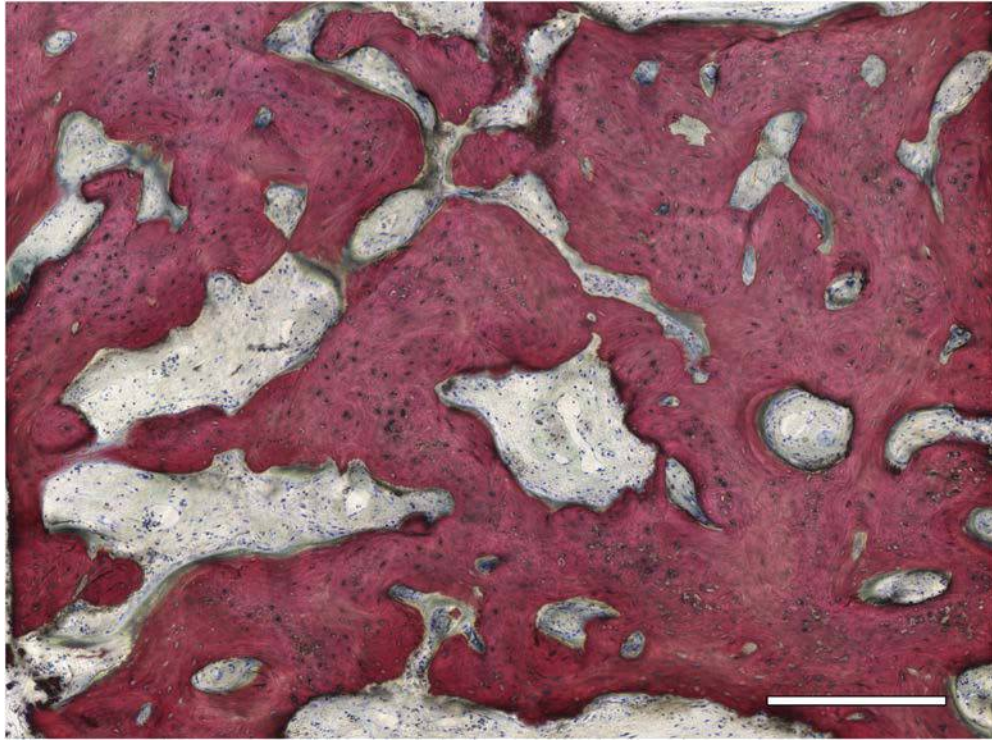


Figure 8: Implants placed in the socket.

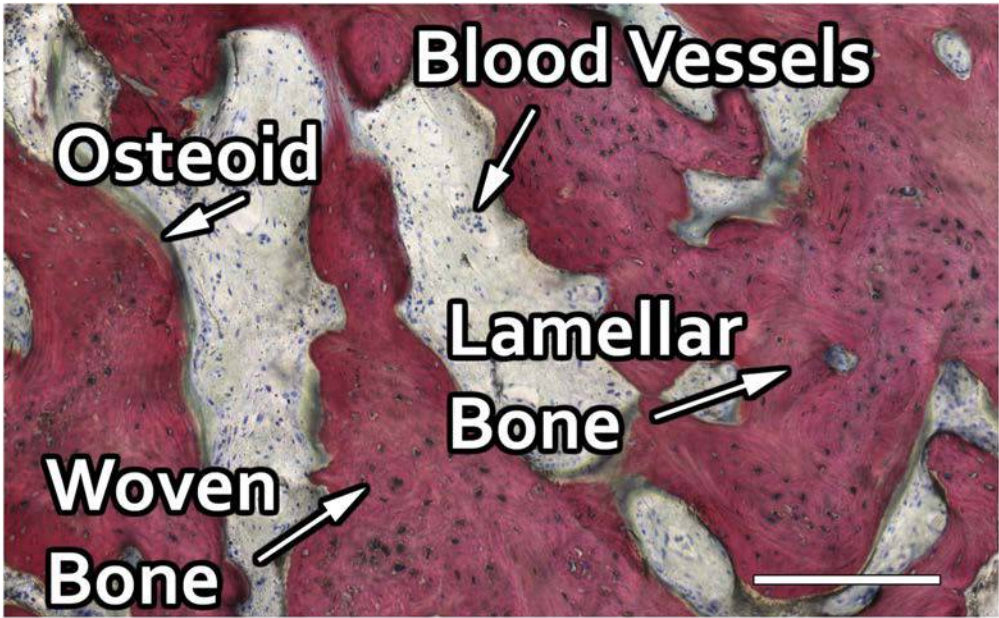
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Figure 9 (a and b): Abutments were placed 4 months after implant placement.



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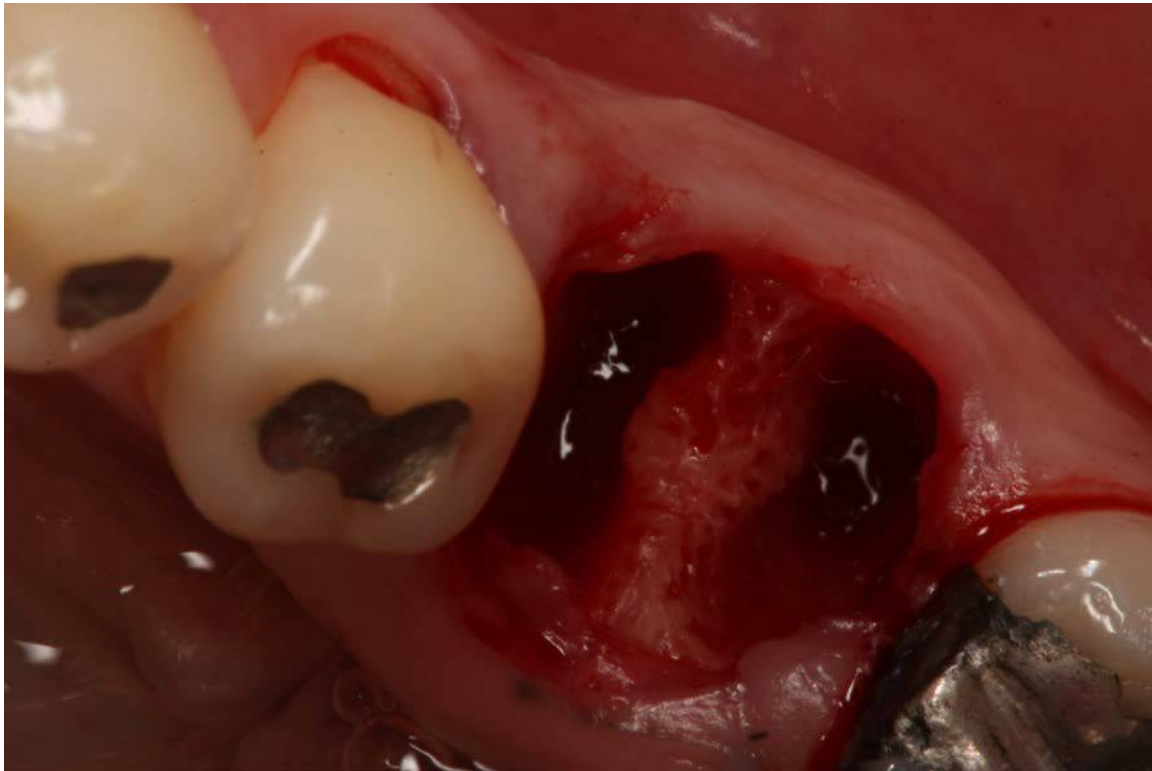


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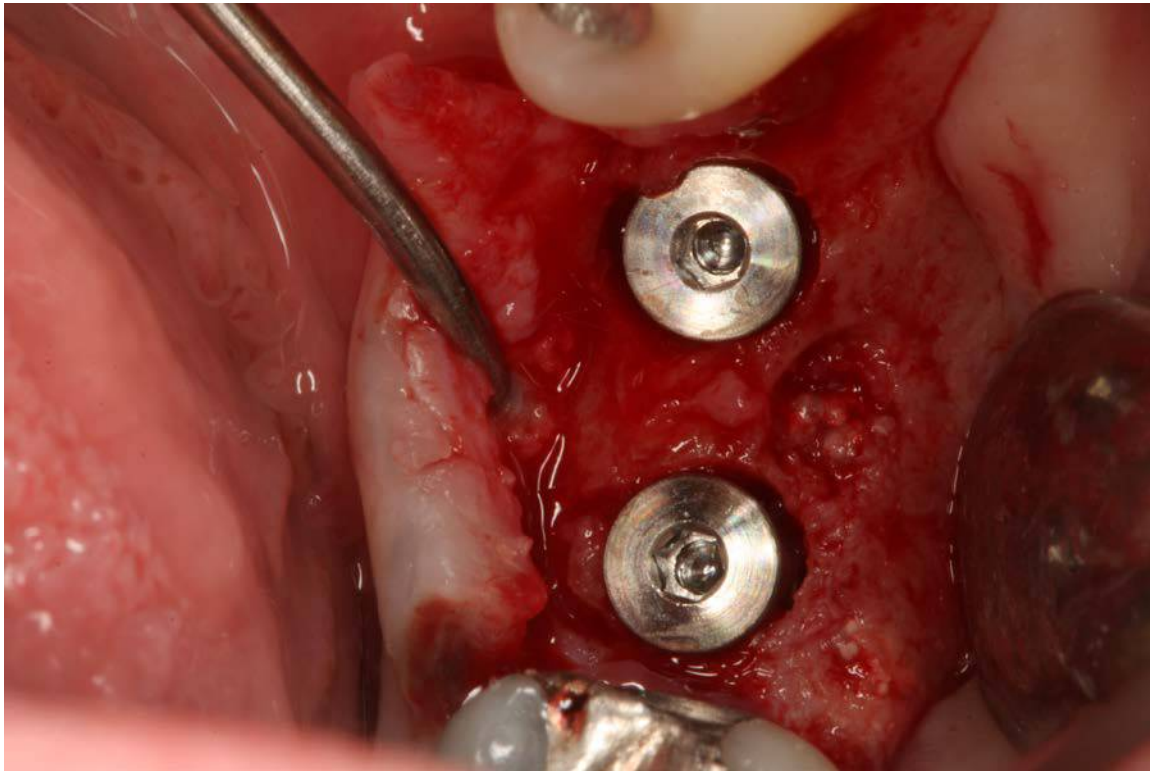
Figure 11: Panaromic radiograph obtained after 18 months.

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