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Biomaterials for bone regeneration in oral surgery:

A multicenter study to evaluate the clinical application of “R.T.R.” (β-Tricalcium Phosphate)

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In Literature there isn’t any conflicting data about the clinical results obtained in Oral Surgery for bone regeneration using Biomaterials of either animal or synthetic origin.\(^{(1)}\)

What is the most important, however, is the creation of a microenvironment suitable for the proliferation and differentiation of hard tissues, such as to successfully promote the regeneration of new bone at the implant-prosthetic purposes.\(^{(1-2)}\)

For this reason, therefore, the Authors always prefer the use of synthetic materials with reduced risk of inflammation and complete absence of potential cross infections.\(^{(1)}\)

The Goal of this study is, therefore, to illustrate - through a case series - short term results of a multicenter research on bone regeneration in Oral Surgery by using an heterologous filling material that consists of β-Tricalcium Phosphate, called R.T.R.

Introduction

International Literature about bone regeneration in implant dentistry describes many different available surgical techniques and the following are the principal:

• Guided Bone Regeneration (G.B.R.)
• Bone Grafting
• Osteogenic Distractions

Each of the above mentioned methods, while presenting different and precise application limits (mostly related to the type of defect and the surgical technique), turned out to be predictable if done correctly.\(^{(2)}\)

The Literature data, then, show how - osteogenic distractions aside - the use of a biomaterial (regardless of its origin, whether animal or synthetic) is helpful if not indispensable to the attainment of an adequate clinical outcome.\(^{(4)}\)

Finally, the use of semi-permeable barriers - whether or not absorbable membranes - rather than metal grids, in order to maintain a suitable...
space, has proved indispensable in G.B.R., while it is still extremely discussed in other regenerative techniques.\textsuperscript{(5)}

In fact, when we speak about Biomaterials in Regenerative Oral Surgery it is appropriate to make a distinction between the following elements:

- \textbf{Semi-permeable membranes}: they allow the stabilization of cloth and the selection of cell lines that will colonize the bone defect (space maintainer = maintenance of biological space).
- \textbf{Filling material}: Support the membrane and act as a "scaffold" for the migration, growth and differentiation of pre-osteoblasts into osteoblasts.

To contribute to the regeneration process, here are the following basic mechanisms of Osteogenesis, understood as a budding center of deputys to the new bone genesis:

- \textbf{Osteoinduction}: stimulation of the differentiation of mesenchymal cells in preosteoblasts.
- \textbf{Osteoconduction}: biological scaffold as a support to new cells in the differentiation process.

It is deduced that the new bone tissue formation occurs if the following organic conditions exist:

- Availability of mesenchymal cells capable of differentiating following the osteoinductive input
- Presence of osteoinductive input ("Osteoinductive Boost"), which initiates the differentiation of mesenchymal preosteoblasts in osteoblasts
- Existence of an osteoconductive environment that promotes the colonization and proliferation of graft.

\section*{R.T.R. (β-tricalcium phosphate)}

Except for autologous bone, on the fundamental concepts of Osteogenesis, remains today still open the debate as to which type of currently available bone grafting material is the best.\textsuperscript{(6)}

Given that, the Authors have carried out a multi-center research about clinical application of a synthetic filler (already known for years on the market) based on β-Tricalcium Phosphate for bone regenerative purposes, called “R.T.R.” (Resorbable Tissue Replacement).\textsuperscript{(6)}

The \textit{Ca}_3(\textit{PO}_4)_2 powder (treated with naphthalene and subsequently compacted by sintering) form the β-tricalcium phosphate, with macropores of a diameter between 100 and 300 microns ideal, that is, for the Osteoconduction.\textsuperscript{(6)}

This heterologous biomaterial, once placed, is completely absorbed in 6 or 9 months, and replaced by new bone.\textsuperscript{(6-7)}

Recent studies on large crestal defects show a significant increase in the regeneration with β-Tricalcium Phosphate already after 2 weeks compared to the other control sites, thereby proving the effectiveness of this filling material.\textsuperscript{(7)}

During resorption, in addition, β-Tricalcium Phosphate provides with Ca ions and phosphate into the site of regeneration: this creates an ideal ionic concentration with an alkaline pH, which stimulates the activation of alkaline phosphatase enzyme, which is essential to the ossification process.\textsuperscript{(6-8)}

Then, all resources of this study and the attention of the authors are focused on the use of β-Tricalcium Phosphate called “R.T.R.” basically because this synthetic biomaterial would possess - as a prerequisite - all the features that a generic filling material should have -with the exception of Osteoinduction.\textsuperscript{(6-7-8)}

These characteristics may be summarized as follows:

- High biocompatibility and minimum autoimmune response
- Bio-inert (absence of local inflammatory reaction)
- Ideal time of resorption for the type of bone defect
- Total reabsorption
- Excellent osteoconductivity
- Good packaging
- High handling during surgery
- Absolutely no risk of cross-infection transmission
In particular, since “R.T.R.” is completely resorbable over a period of time, reasonably useful for important bone defects resolution, the authors think “R.T.R.” is particularly appropriate for all regenerations conducted for the purpose of implant-prosthetic rehabilitation, in contrast with many other filling materials that do not resorb completely - and allow only a repair instead of a healing of the bone defect. (8-9)

Materials and methods

This multicenter Study provides for the regeneration of bone tissue with β-tricalcium phosphate “R.T.R.” in patients with a residual bone defect of the maxillary and with implant-prosthetic rehabilitation purposes. The selection of patients is randomized. However, in order to standardize the number of cases, this random selection requires that patients have the following basic requirements:
- Aged between 20 and 60 years
- Either male or female
- Non-smokers
- In good general health
- Having at least a residual crestal bone defect

Regarding the type of defect, it is deliberately excluded to standardize the same, in terms of morphology and etiopathogenesis, in order to verify the regenerative effectiveness of “R.T.R.” in different conditions of bone atrophy (and, therefore, of different “regenerative thrusts”). It is, therefore, decided to treat the following clinical situations:
- Post-extractive sites
- Bone regeneration around implants placed in areas with deficiencies in bone or post-extraction
- Overall G.B.R. (sinus lift or major bone defects)

Case series

The Authors, from 4 different cities and from different working situations (private practice, hospital and private clinic) have treated 12 patients with the following bone defects:
- N 3 peri-implant defects
- N 2 sinus floor lifts
- N 4 post extractive sockets
- N 3 bone defects of various types

In all cases, the patients were subjected to antibiotic therapy with 200 mg / day of Doxycycline (in 2 doses daily beginning the day before surgery up to 8 days after the intervention), to daily repeated rinses with chlorhexidine and therapy with FANS as needed (Ibuprofen 800 mg / day in single-dose).

Case Report no.1

The first is a case report of a 54-year-old male patient, in good health general conditions, with a mandibular residual cyst in area 46. (Fig. 1-2-3)

In accordance with the patient, we opted for an intervention of Partsh II, filling the remaining cavity with R.T.R. granules without using semi-permeable membranes. (Fig. 4-5-6-7-8)

About 6 months after the first surgery, the next step will involve the placement of one implant. The local objective examination and routine radiographic examination showed a good healing short-term. (Fig. 9-10-11)
Fig. 1-2-3: Mandibular residual cyst in area 46.

Fig. 4-5-6-7-8: Intervention of Partsh II and filling of the remaining cavity with R.T.R. without using semi-permeable membranes.

Fig. 9-10-11: The local objective examination and routine radiographic examination showed a good healing short-term.
Case Report no.2

The second case report is a 45-year-old female patient, in good general health conditions with edentulous in area 25-26 and progressive atrophy of the corresponding alveolar process. 
(Fig. 12-13)

In accordance with the patient, by full-thickness mucosal flap in the area 25-26, we opted for a transcrestal sinus floor lift with a R.T.R. graft and simultaneous placement of two fixtures. In this case R.T.R. has been used also as a filling material around implants contextually.

For this case the syringe form of R.T.R. has been chosen. The fixtures had a good primary stability, equal to about 60 newtons. (Fig. 14-15)

The subsequent exposition of the implants and the beginning of the prosthetic phase will be managed about 6 months after sinus lift procedure.

The good health of the superficial soft tissues and surveys Rx screening show the excellent health of deep tissues in short term. (Fig. 16-17)
Case Report no.3

The third case report involves a 52-year-old female patient, in good general health conditions, who has been subject to avulsion of the elements 16 and 17, because they were irreparably compromised and extremely symptomatic. (Fig. 18-19-20)

In area 16, for regenerative purposes, has been executed a graft of R.T.R., presented in a cone with collagen. (Fig. 21-22-23-24-25)

About 6 months following R.T.R. graft will be positioned an implant.

Also in this clinical case as in the others the local objective examination and the Rx screening showed an excellent recovery in the short term.

Fig. 18-19-20: Avulsion of the elements 16 and 17 due to a severe periodontal defect.

Fig. 21-22-23: In area 16, for regenerative purposes, has been executed a graft of R.T.R.

Fig. 24-25: Immediate post op clinical and radiological situation.
Discussion

The post-surgical follow-up in the short term (which provides an objective local examination and Rx control after 8 days and also in following weeks after the first surgical step) showed that in all cases treated were found the following items:

- Good immediate healing of superficial soft tissues
- Excellent radiographic condition of deep tissues
- Absence of autoimmune reactions
- Absence of local reactive inflammation
- Absence of excessive bleeding

The authors also confirm that R.T.R. material, besides having a packaging extremely functional, has expressed high qualities of practicality and manageability during the surgical procedure, in its mode of use, application and compaction (in all the forms of packaging).

The on-going research, currently in the initial phase, involves a series of stages, in which will also be performed (if and where possible) the implant-prosthetic rehabilitation of bone defects treated and, if possible, a histological evaluation suitable to document the degree of absorption and regeneration.(10-11)

Conclusion

The interesting initial and partial results obtained to date are encouraging for the authors to continue the study in progress. The goal remains to propose a predictable therapeutic solution, though alternative and not a replacement of the other existing and fully described in the Literature. (12-13-14-15-16)

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In order to obtain effective bone regeneration using natural or synthetic fillers, a series of favourable conditions must occur that allow the body to perform the bone growth (15) as follows:

- presence of a blood clot with a high concentration of mesenchymal stem cells (MSC) capable of evolving in the osteoblast line and of endothelial cells forming a rich vascular network
- presence of vital bone tissue, from which osteogenic and angiogenic cells originate through adequately prepared surrounding bone (cortical perforation)
- stabilization and maintenance of volume underneath the membrane
- protection of blood clot with a membrane, with the function of the stabilization of the clot, protecting growing vascular structures and blocking the migration of epithelial cells, which proliferate faster than bone cells.

In 1980 Nyman and Karring first introduced the concept of guided tissue regeneration (GTR) of
periodontal tissues, showing that the cells of soft tissue can grow faster than bone tissue (10). Thus, based on the results obtained, the migration of soft tissue cells above the implanted material must be stopped, thereby blocking migration within the porosity of the same material, thus promoting osseointegration rather than fibrointegration. The main characteristic of a membrane should be semi-permeability, i.e. the presence of porosity approximately 22 microns in diameter. Initially, a thin vascular network and a primary fibrous osteoid tissue - also called primary spongiosa - will begin to form within the clot. The latter is later mineralized thanks to osteoblasts that cover its surface, forming a new poorly calcified cortical bone. The process stops when intertrabecular spaces narrow due to the formation of new bone tissue, until they reach the characteristic dimensions of Havers channel which, along with concentric lamellae, originate primary osteomas. All this occurs during the first 3-4 months, though actual bone remodelling requires more time, as it creates secondary spongiosa. Research conducted by Hämmerle in 1996 (11) on human subjects confirmed what had previously been observed in animals, i.e. in the presence of large bone defects, regeneration can be limited to the more peripheral areas of the defect, while less activity is observed in the central area, where granules of biomaterial remain over time, though less frequently when tricalcium phosphate is used. The process of ossification always starts from the walls of the defect toward the center of the clot, along the newly formed vessels. A number of studies clearly describe the regenerative ability of autologous bone compared with synthetic biomaterials, but unfortunately not without negative aspects. Indeed, collection from the donor site is very often painful for the patient; additionally, this results in longer surgical procedures and postoperative pain; finally, the implanted material has a high degree of resorption (not a negligible factor). The materials used for bone regeneration are grouped into: Autogenous bone, allogenic bone, xenogenic bone, alloplastic bone.

Graft biomaterials

The alloplastic biomaterials available on the market represent an excellent alternative to autologous bone graft and are classified into two large groups: bioinert and bioactive, according to their interaction when they come into contact with the receiving site. The main requirement of a synthetic biomaterial is to have a surface porosity that must promote colonization and development within its structure. These porosities must measure between 200/400 microns in diameter (Lynch et al., 2000; Bauer and Muschler, 2000). Synthetic biomaterials have been the subject of many studies, though their long term results have not always been considered. (1-2-3) Today, osteoblastic cells or bone morphogenetic proteins (BMP obtained with in vitro cultures) can be added to a graft material (4-5) to enhance its osteoinductive and osteoconductive abilities and therefore reduce the time required for cells colonization. (6-7-8) Among alloplastic biomaterials, β-tricalcium phosphate is the one that mostly displays a stable bond with bone neoformation; indeed, its characteristics have made it suitable for use in orthopedics since the early 1900s. In the presence of H2O it becomes instable, turning into hydroxyapatite, and this characteristic makes it suitable as an osteoconductive material (Coetree, 1980, De Leonardis and Pecora, 1999; 2000). β-TCP is characterized by a lower Ca/P ratio, which makes it more soluble than natural apatite. The Beta form is commonly obtained by mixing calcitis (CC) and dibasic calcium phosphate anhydrous (DCPA). The product obtained is rapidly cooled, and Alfa-TCP is obtained. Conversely, extended repeat baking at 800/950°C results in the beta form (9-12-13). Multiple studies conducted on the TC and bone interaction have shown that histological examination at four months shows an initial bone neoformation in the intergranular spaces and in the surface porosity that helps guided bone formation. Indeed, the granules are reabsorbed by phagocytosis, releasing Ca/Mg and phos-
phates in the surrounding bone tissue, thereby activating alkaline phosphatase, a key ossification process. Between 6 and 18 months, fibroblasts begin invading the biomaterial, activating the extracellular dissolution process which ends with the calcification phase. If this should occur sooner, graft integration, rather than biodegradation, would happen. (5-6-7-8).

R.T.R.

Synthetic, biocompatible and totally resorbable 99% pure tricalcium phosphate bone replacement, available in granules and in a cone shape, for regeneration in periodontal defects, implant, post-extraction bone defects and bone lesions following endodontic surgery.

The micro and macro-porous R.T.R. structure, with macropores measuring between 100 and 400 µm and micropores measuring less than 10 µm. These morphological characteristics allow excellent osteogenic cell in-depth colonization and easy compacting.

Unlike hydroxyapatite, R.T.R. is progressively and totally reabsorbed, thereby releasing calcium and phosphate ions that participate actively in the formation of new bone tissue. Over a period of time between 6 and 9 months, which may vary according to the patient’s physiological response, while stimulating bone regeneration, R.T.R. is progressively reabsorbed, leaving space for bone neoformation.

Indications:
- Post-extraction sites
- Filling post-extraction sites to maintain the dimensions of alveolar bone
- Implant defects
- Sinus lift procedure
- Reconstruction of peri-implant defects
- Filling periodontal pockets with two or more walls
- Residual cavities after oral surgery (like cyst)
- Filling defects after apicectomy
- Alveolar filling following extraction of impacted teeth.

Materials and methods

We conducted a multicenter study to evaluate the clinical application of R.T.R. (β-tricalcium phosphate).

This study examines the regeneration of bone defects with R.T.R. (β-tricalcium phosphate) in patients eligible for prosthetic implant rehabilitation. Patients were randomly selected, according to the following key criteria:
- aged between 20 and 60 years
- either male or female
- non-smokers
- in good general health
- having at least one crestal bone defect (no morphology and etiopathogenesis restrictions).

The cases treated were identified in the following clinical situations:
- Post-extraction sites
- Bone regeneration around implants placed in areas with bone loss or post-extraction.
- GBR (sinus lift or major bone defects).

In all cases, patients received antibiotic therapy with 1 gr every 8 h of Amoxicilline plus Clavulanic Acid (starting 24 hours before surgery up to day 5 post-surgery), repeated daily rinses with chlorhexidine and therapy with FANS (ibuprofen 800 mg/day in single dose), as necessary.
Case Report no.1

Patient: Female
Age: 30
History: Odontogenic cyst in maxillary bone at 2.1.
Cyst was removed in October 2013. Vertical guided regeneration with resorbable membrane and R.T.R. was performed. Implant placement: bone peak follow-up intraoral X-ray in consecutive months. 2nd surgery ISQ value: 61.

Fig. 1-4: Different projections of radiographic C.T images show the large bone defect in site 2.1.

Fig. 5: Temporary prosthesis to cover the cosmetic defect.

Fig. 6: X-ray image before grafting.
Fig. 7: X-ray image after 5 months.
Fig. 8: X-ray after insertion of the implant.
Fig. 9: The local objective examination and routine radiographic examination showed a good short-term healing.

Fig. 10: The ISQ test confirms a good stability of the implant.
Fig. 11: To obtain a good aesthetics of the final prosthesis is important to condition the soft tissue with the healing screws that favors the emergence profile.
Case Report no.2

Patient: female
Age: 60
History: large cyst in upper maxillary bone extending from 2.2 to 1.1.
The cyst was removed and the cavity was filled with R.T.R. enhanced with PRGF (platelet-enriched plasma) and simultaneous placement of five implants was also performed.

Fig. 12-13: Presence of large cysts of 2.1. The oral cavity examination shows a poor oral hygiene.

Fig. 14-15: Removal of the cyst; it is very important to remove all residual epithelial.

Fig. 16-17-18: Filling the bone cavity with granular R.T.R.

Fig. 19-20: During the same surgery were included five implants.

Fig. 21: X-ray control after five months.
Case Report no.3

**Patient:** female  
**Age:** 50  
**History:** severe atrophy of the alveolar ridge, upper right jaw, affecting the area of 1.3, 1.4, 1.5, 1.6. These teeth were extracted and the alveolar ridge was reconstructed with R.T.R., covering biomaterial with Tabotamp (oxidized cellulose).

*Fig. 22-23:* Resorption of the alveolar process caused by periodontal disease. The local examination shows the class III mobility of the teeth.

*Fig. 24-25-26:* Resorption of the alveolar process caused by periodontal disease. The local examination shows the class III mobility of the teeth.

*Fig. 27-28:* Use of Tabotamp to cover the graft.

*Fig. 29-30:* The local examination after 10 days.

*Fig. 31-32:* The radiographic image after 4 months showed an increase in the vertical dimensions.
Case Report no.4

Patient: female
Age: 30
History: root fracture of 1.6, previously treated with root canal treatment and large crown composite reconstruction. The roots were carefully extracted, and an implant was placed, using the interadicular septum bone and by performing an elevation of the maxillary sinus with osteotomes. The alveoli were filled with R.T.R. and covered with a collagen membrane.

Fig. 33-34: Fracture of the first molar with the insertion of implant with post-extraction procedure.

Fig. 35-36-37: Extraction was performed with piezosurgery technique to preserve the alveolar bone.

Fig. 38-39-40: The gap was filled using R.T.R.-size cone.

Fig. 41-42: The intraoral examination and radiographic examination after 4 months showed good integration of the implant.
Case Report no.5

Patient: female
Age: 64
History: loss of 2.2 and 2.3 due to trauma.
CT revealed a significant resorption of buccal vestibular alveolar process.
Two implants were placed (measuring 3.3 mm in diameter and 13 mm long) and the gap was filled with R.T.R.
Re-opening was done after 5 months and evaluation of osteointegration with Osstell.
2.2 showed a value of 22-ISQ, and 2.3 –ISQ 64.

Fig. 43-44-45: Severe post-traumatic atrophy of the alveolar process in place 2.2-2.3.

Fig. 46-47: Insertion of two implants with “split-crest” surgical technique.

Fig. 48-49: The gap between the two margin bone was filled with phosphate-tricalcium R.T.R.

Fig. 50: X-ray control after 4 months showed a good bone density.

Fig. 51-52: The intraoral examination does appreciate a good recovery and an increase in bone volume.

Fig. 53-54: The ISQ value confirms a good osseointegration.
Case Report no.6

**Patient:** female

**Age:** 55

**History:** residual cyst at 3.6. To proceed to prosthetic molar rehabilitation with an implant, the cyst was extracted and the cavity was filled with R.T.R.; after a 4-month period for bone regeneration, the implant was placed.

**Fig. 55-56:** The C.T. examination before surgery showed a residual cyst.

**Fig. 57-58:** After having removed the cyst, to speed up the healing time, the cavity has been filled with R.T.R. granules.

**Fig. 59:** Wound at 30 days.

**Fig. 60:** X-ray at 3 months.

Conclusion

Based on the results obtained in the short term, the authors confirm the excellent properties of R.T.R., both in the first weeks of healing and in the following months, and they consider it an excellent alternative to autologous bone grafts. No inflammatory reactions or loss of bone volume evaluated clinically and radiographically occurred in any of the cases examined. The most encouraging data came from the observation of the compactness and density of the bone neo-formation, which easily allowed the placement of implants with high ISQ values both during and after the placement of R.T.R. graft.
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β-tricalcium phosphate used with onlay graft for horizontal bone augmentation yielded preferable result: a case report

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Introduction

Rehabilitation of teeth lost due to disease, trauma, surgery or congenital problems with implant-supported prosthesis has become a common practice worldwide. (1) However, various bone defects often exist in implant area. In some severe atrophic cases, alveolar bone must be restored before or in combination with implant placement. Bone augmentation using onlay bone grafts which are harvested from either intraoral or extraoral sites is currently one of the most reliable techniques with potential success rate. (2,3) However, the use of autografts only as onlay grafts has some drawbacks such as the high morbidity at the donor site, limited bone graft supply and the need for multiple surgical sites. (4,5) Therefore, synthetic bone graft materials have become a popular choice for bone augmentation during last decade and the application of different bone substitutes has been described in different oral surgeries. (6.7.8.9) Recently, the synthetic bone graft based on β-tricalcium phosphate which can be completely absorbed in 6 to 9 months has been reported to be used in different oral surgeries such as alveolar preservation and periodontal defects with satisfactory clinical and histologic results. (10.11.12) Tricalcium phosphate grafts has structural characteristics which is similar to bone tissue, moreover, during reabsorption it can provide ion calcium and magnesium for surrounding tissue, thus creating a correct ionic environment, which could activate more alkaline phosphatase for further bone synthesis. (13) The purpose of this case report is to present clinical and radiographic results for a patient treated with β-TCP bone substitute with autogenous bone block harvested in situ as onlay grafts for horizontal bone augmentation.
Case Report

A 36 year-old healthy male with good oral hygiene required implant supported prosthesis for his two maxillary central incisors and right lateral incisor (tooth 11,12,21). (Fig.1,2) Pre-surgery radiographic examination showed insufficient bone volume for placement of implants 3.3 mm in diameter. (Fig.3) After administration of local anesthesia, crestal and vertical incisions were made to expose the labial surface of the absorbed alveolar ridge and two autogenous bone block was harvested apical to the recipient site from the basal base and β-TCP bone graft (RTR Syringe package, Septodont, France) was placed in the donor site and dressed on the autogenous block. (Fig.4-9) Then the incision was closed after a titanium mesh and a barrier membrane was covered. (Fig.10) Routine anti-inflammatory therapy and prophylactic antibiotics were prescribed.

Six months later, a reentry surgery was performed. The bone graft material has been replaced by new formed bone which is an inspiring result as compared with six months ago. Two implants were inserted at tooth 12 and 21 with good primary stability. (Fig.11-13) CBCT examinations presented favorable outcome of the horizontal bone augmentation. (Fig.14-15)
Fig. 6: Use the filter of the syringe package sucking blood in surgical area.

Fig. 7: Fix two blocks on the alveolar ridge with titanium screws.

Fig. 8: Inject R.T.R. graft into the donor site.

Fig. 9: Finish dressing R.T.R. graft on the blocks.

Fig. 10: Flap closed with a releasing incision.

Fig. 11: Occlusal view six months later.

Fig. 12: Horizontal alveolar ridge was augmented by new formed bone.

Fig. 13: Two implants were placed in the anterior maxillary.

Fig. 14: CBCT of tooth 12 immediately after bone augmentation, six month later and immediately after implantation.

Fig. 15: CBCT of tooth 21 immediately after bone augmentation, six month later and immediately after implantation.
This case report showed the potential advantage of β-tricalcium used with onlay graft for bone augmentation. The clinical and radiographic results show that this synthetic graft has been replaced by new formed bone six months later. Among all the graft materials, tricalcium phosphate is of special interest because it is a resorbable and osteoconductive biomaterial. (15) The in vivo osteoconductivity of synthetic bone graft is dependent on several properties including surface morphology, chemical composition and geometry at both the macro- and micro-scale. The pore size and interconnectivity of biomaterials can significantly influence the exchange of fluids through grafts and the delivery of ions, nutrients within and through the bone substitute. (16,17,18)

The bone graft used in this case consists of pure β-tricalcium with an appropriate macro- and micro-scale which turn to be good osteoconductivity and make this graft a potential scaffold for osteoblasts. Moreover, pure β-TCP can be totally absorbed in 6 months thus leaving no residuals in the implant area which may influence the remodeling of bone regeneration. (15) β-TCP used with autogenous bone block as onlay graft for anterior bone augmentation in this case gained inspiring result which is a motivation for more oral surgeons to conduct similar cases. Despite the favorable result of the primary surgery, long term observation is still needed for a series of clinical cases.

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References

Bone regeneration with β-tricalcium phosphate (R.T.R.) in post-extraction sockets

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Two clinical cases are presented in which β-tricalcium phosphate "R.T.R." (Septodont) was used for post-extraction bone regeneration to preserve the alveolar ridge in height and width for future dental implants placement. Resorption of the filling material is demonstrated by a histological study as well as good clinical and tomographic results.

Introduction

The dimensions of the alveolar ridge may be seriously affected following dental extraction as a result of normal alveolar bone remodelling.\(^1,2\) Although the bone loss occurs in both the horizontal and vertical aspects, greater bone loss is observed in the horizontal dimension.\(^3\) Schropp et al.\(^1\) found that the greatest loss of alveolar height occurred during the first 3 months and less than 50% of the width of the ridge was lost after 1 year. Other studies observed losses amounting to 40% of height and 60% of width after only 6 months.\(^3,4\)

During the 80's and in the early 90's, bone grafting procedures were commonly performed using autogenous bone or fresh frozen allografts, but the advent of efficient and safe processing and the sterilisation techniques led to an increasing use of bone graft substitutes for the procedures of periodontal regeneration and alveolar ridge augmentation.\(^7,8\)

The main advantages in using bone grafting substitutes are their unlimited availability and the reduction in the morbidity associated with the harvest of autologous bone at a second intraoral or extraoral surgical site.\(^9\) The development of synthetic or combined biological-synthetic alloplastic materials for bone regeneration has become more widespread during recent years. This type of material may integrate or resorb completely, forming lamellar bone at the site. Inorganic ceramics based on calcium phosphate (α-tricalcium phosphate, β-tricalcium phosphate and hydroxyapatite) contrast with bone regeneration materials of biological origin in the sense that the synthetic materials have their physical and crystallographic characteristics clearly defined in addition to the chemical properties (chemical composition and purity).\(^11\)
β-tricalcium phosphate has been used in various studies in animals and in humans in order to demonstrate its efficiency as a bone regeneration biomaterial.

**Aims**

Histological, tomographic and clinical evaluation of alveolar ridge preservation in width and height following the insertion of β-tricalcium phosphate “R.T.R”. (Septodont) in post-extraction sockets for future dental implants placement.

**Materials & Methods**

In order to be able to observe whether the alloplastic filling material, β-tricalcium phosphate “R.T.R.” (Septodont) resorbs completely, a histological study was performed 12 months after grafting the material in the alveolar socket, the biopsy being done at the time of implant placement. This material was used in cone presentation when the post-extraction socket was well preserved by atraumatic extractions. However the material was used in syringe presentation combined with resorbable membranes in bone defects in which the vestibular bone plates were lost. Absorbable polyglycolic acid sutures of 4/0 zeroes with a sharp needle 3/8 circle were used. The grafted sockets were observed radiographically after 6 and 12 months.

**Results**

The material’s ability to resorb and form new bone yielded excellent results, demonstrated by a histological study done 12 months after placement, as well as by a case of bone regeneration using a membrane (imminent vestibular destruction), for which a control tomography was performed after 18 months showing excellent results.

The results obtained in this study confirm the main observations of other clinical and experimental studies performed any other groups of professionals.

**Case Report no.1**

A 29-year-old woman came with a fistula at the level of tooth 2.5; grade II tooth mobility. On X-ray examination, a radiopaque image was observed in the canal showing a post and core restoration; periapically, a radiolucent lesion was observed, potentially revealing an infectious process.

![Fig. 1: Presence of the fistula at tooth 2.5.](#)

![Fig. 2: Fistulography (cone no. 25).](#)

![Fig. 3: Panoramic X-ray.](#)
The tooth was extracted and the β-tricalcium phosphate filling material “R.T.R” (Septodont) was placed, without a membrane; a partial thickness flap was raised in order to cover the graft and the wound was sutured using 4/0 polyglycolic acid sutures with a sharp needle 3/8 circle. She was prescribed: Amoxicillin 500 ml/clavulanic acid 125 mg once every 8 hours x 5 days. Ibuprofen 400 mg once every 8 hours for 3 days. Soft diet x 48 hours. The sutures were removed after 2 weeks. She was advised to get X-ray controls after 3, 6 and 12 months. After 12 months, the patient returned for consultation; she had been unable to do so before for reasons beyond her control. A clinical examination was performed (Fig. 8) in addition to a periapical X-ray with a metal mesh (grip). On the periapical X-ray done after 12 months a circumscribed radiopaque image, round in shape, was observed in the area of the graft as if it were apparently an encapsulation of the material (Fig. 9).
After 12 months, it could be clinically observed how the alveolar ridge had been maintained both in width and height and in order to verify whether the β-tricalcium phosphate (R.T.R.) had resorbed completely, we took a sample from the area to be implanted and performed a histological study (Fig. 10).

The treatment plan was thoroughly implemented for a correct insertion and placement of the dental implant. We knew that computerised axial tomography would provide a more precise diagnosis with respect to bone width and height. However since a single dental implant was involved and moreover a fairly well preserved ridge was clinically observed, we used the clinical mapping method.

Doing our measurements, we had a palatine vestibular width of 8 mm and a width of 7 mm mesiodistally. The calculation of the height using the periapical X-ray done with metallic mesh (grip) and a parallel method gave us an approximation of the actual height, which was 10 mm. After obtaining all the measurements of 8x7x10mm, it was decided to perform maxillary sinus lift using Summer’s technique.

**Dental implant placement**

Using a trephine drill 2 mm in diameter, we removed bone tissue from the alveolar ridge for its histological study in which we wanted to find out whether the β-tricalcium phosphate (R.T.R.) had resorbed completely. The sample was placed in 10% formocresol.

Then we positioned our surgical guide in order to perform the sequential drilling for implant placement, using helical drills; a control X-ray of the preparation was taken, inserting a paralleling pin in the alveolar socket (Fig. 12b), which showed us correct parallelism with the preparation; it was observed how the paralleling pin remained exactly 2 mm away from the sinus floor (Fig. 12c), since it was taken with a grip; then Summer’s technique was performed approach to the Schneider membrane using osteotomes, from crestal bone leaving 1-2 mm of residual bone before the floor of the maxillary sinus.

This dimension of bone was increased by means of pressure, pushing the membrane upwards.

![Fig. 10](image1.png): a) Tissue sample, removed using a 2mm trephine drill, in the area in which the dental implant is to be inserted. b,c) Histological results after 12 months. Haematoxylin-eosin tincture under light microscopy. New bone formation at the level of the β-tricalcium phosphate absorption site.

![Fig. 11](image2.png): Clinical mapping. a) Placement of the saddle-shaped acrylic on the area for taking of measurements, tooth 2.5. b) Taking of measurements (file no. 25). c) Transfer of measurements to the trimmed model.
without perforating the latter and creating the space required to place biomaterials or the implant.

Once the sinus floor elevation was achieved, which could allow a gain between 3 and 4 mm in height 13-15, the implant, Conexão of 11.5 x 4 mm cylindrical internal hexagon, was inserted; in this case we succeeded in elevating the sinus floor by 3.5 mm. (Fig. 13)

Finally, a partial thickness flap was performed with 2 liberating incisions in order to be able to confront the soft tissues in the palatine direction; figure-of-eight sutures and X (cross) sutures were inserted in order to protect the tissue and avoid collapse; the liberating incisions were sutured with circumferential sutures. Vicryl 5/0 zeroes was used for synthesis (Fig. 14 a). The postoperative X-ray was performed confirming the elevation of the sinus floor by approx. 3.5 mm. (Fig. 14b)

She was prescribed: Amoxicillin 500 ml/clavulanic acid 125 mg once every 8 hours x 5 days. Ibuprofen 400 mg once every 8 hours for 3 days. Soft diet x 48 hours.

The sutures were removed after 2 weeks. The patient was advised to wait for 6 months for osseointegration. The results of the histological study showed bone neoformation with absence of β-tricalcium phosphate (R.T.R.) filling material.
Fig. 14: Full thickness flap and suture with Vicryl 5/0 zeroes. g) Postoperative X-ray showing the 3.5 mm maxillary sinus lift achieved using Summer’s technique.

Implant activation

Fig. 15: Open-tray impression taking, application of transfer and analog on the impression.

Fig. 16: Prepared abutment and application of the porcelain crown.
A 54-year-old woman came with grade III tooth mobility at tooth 1.1. On X-ray examination, a radiopaque image was observed in the canal showing a post and core restoration. The patient presented with an obvious root fracture on clinical examination. Atraumatic extraction of the tooth was performed, then the guided bone regeneration procedure with ß-tricalcium phosphate (R.T.R. - Septodont) was done, in addition to the use of a resorbable membrane. A partial thickness flap was performed in order to cover the graft and the membrane, the wound was sutured using 4/0 polyglycolic acid sutures with a sharp needle 3/8 circle. The sutures were removed after 2 weeks. She was recommended to get X-ray controls after 3, 6 and 12 months.

Fig. 1: Initial photo. Tooth 1.1 with extrusion and grade III mobility.
Fig. 2: Initial X-ray. a) Tooth 1.1, presence of an excessively wide post and core, the probable cause of root fracture. b) X-ray with grip.
Fig. 3: The major root fracture can be confirmed when raising the full thickness flap.
Fig. 4: Extraction of tooth 1.1, loss of the vestibular bone plate due to the fracture which remained for a long period in the mouth.
Fig. 5: R.T.R. in cone presentation.
Fig. 6: Major vestibular bone loss.
Fig. 7: Placement of the R.T.R. cone.
Fig. 8: Modelling of the R.T.R. cone.
Conclusion

- β-tricalcium phosphate (R.T.R.) has proven to be a good osteoconductive material for bone regeneration following the filling of a post-extraction socket, allowing the preservation of the alveolar ridge in order to place a dental implant.
- Its ability to resorb and form new bone yielded excellent results, demonstrated by a histological study done 12 months after placement, as well as by a case of bone regeneration using a membrane, since vestibular destruction was imminent, where a control tomography was performed after 18 months showing excellent results.
- It is easy to use and handle.
- The results obtained in this project confirm the main observations of other clinical and experimental studies performed any other groups of professionals.
References


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Use of R.T.R. and PRF as filling material in post extraction sockets

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Introduction

Currently, the great majority of the extractions are followed by the immediate use of an implant. In some cases the bone volume is not enough to get the desired primary stability, in that case the clinician will need a first surgery where he would win the bone volume required for that implant, and then a second surgery for the final placement of the implant. To obtain the best results possible, the use of a material that guides the bone regeneration is necessary and ß-tricalcium phosphate has proven a great efficacy in helping and maintaining the space for the bone regeneration. In addition to this, the use of platelet rich fibrin (PRF), a second generation platelet concentrate, that acts as a bioscaffold and has multiple growth factors, can accelerate the process of regeneration. The characteristics of R.T.R. are its porosity, that helps in the formation of stronger clots, no systemic toxicity and its resorbability that promotes new bone formation in 3 - 6 months. In synergy with this, PRF thanks to its growth factors promotes the new bone formation and, as an optimized clot, helps to get a faster regeneration of the extraction socket and to have a more predictable outcome.

Case report

A 59 year-old woman, systemically healthy and under periodontal treatment, requires the extraction of the left central incisor (2.1) and left lateral incisor (2.2) to be rehabilitated with osseointegrated implants in a second surgery after the alveolar preservation surgery. The lateral incisor presents a radiolucent lesion around the root and no presence of vestibular wall in 2.1. The surgery was explained to the patient with the risks and benefits and an informed consent was signed. Local anesthesia was administered to the patient. The teeth were extracted with a forceps taking care to preserve the alveolar walls. After the extraction, a full mucoperiostal flap was elevated which allowed to confirm the great loss of alveolar bone.
Two blood tubes of 9 ml without anticoagulant were obtained from the patient’s ante cubital vein for the production of the PRF. The PRF was produced following Choukroun protocol (3000 rpm by 10 min)\(^6,\)\(^7\) and then compressed into two membranes\(^8,\)\(^9\). The exudate of the compression was collected with a syringe to be applied over the bone graft. One of them was cut and mixed with R.T.R. fragments to be used as the bone graft and the other one was used as a membrane\(^6,\)\(^7\).

R.T.R. was fragmented to get a better adaptation to the defects, and once mixed with the PRF membrane, it was placed in the defects. When the graft was ready the exudate was then applied to it. When suturing, the membrane was applied with a pocket technique to ensure its intimate contact with the bone graft\(^10\). The flap was closed with simple stitches and in first intention.
The use of platelet concentrates has become popular during the last 10 years, but among them, one of the simplest and cheapest form has raised as one of the best options, the PRF. As a cheap and free access platelet concentrate, its homogenous bibliography supports its good results as an adjuvant in multiple surgeries like sinus lifts, intrabony defect fillings and of course bone grafting\(^6\)\(^-\)\(^7\). Although PRF acts as a bio-cathode, it lacks a good resistance and resorbs in around 28 days, thus the use of a material that sustains bone regeneration is necessary, and that material is R.T.R.

Beta-Tricalcium Phosphate has a proven biocompatibility, osteoconductivity and resorbability. As it resorbs, R.T.R. releases calcium and phosphate ions which help in the neo formation of the bone\(^1\)\(^1\).

The combination of two materials with not known local or systemic toxicity and that synergize in the formation of bone should reduce the time needed to place the implants. The bone graft that best suits the PRF characteristics still needs further and deep study, but R.T.R. seems to perfectly fit all the characteristics to maximize the bone regeneration.

\(\text{Discussion} \)
References


Alveolar Ridge Preservation With Alloplastic Material

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Introduction and objective

Alveolar ridge preservation is done when it is expected that following a tooth extraction this part will be rehabilitated by an implant to minimize the bone resorption that occurs during the biological healing of the socket. Current studies allow us to expect that, with the alveolar ridge preservation technique, we will decrease the volume loss by around 1 mm in height and 3 mm in width.1

Different techniques and materials have been used in recent years, all based on three biological mechanisms that promote alveolar healing: 2-4
- Osteogenesis: formation of new bone from viable and precursor osteoblasts, transplanted with graft material.
- Osteoinduction: formation of new bone by differentiation of local connective tissue cells in bone-forming cells, under the influence of one or more inductors.
- Osteoconduction: formation of new bone by the network generated by a non-vital graft material, which allows the penetration of precursor osteoblasts present in the defect. The various types of grafts can be classified according to their origin in: autografts, allografts, xenografts, and alloplastic materials.
- Autografts: bone grafts that come from a donor area of the same individual. They are osteogenic, but have high resorption.
- Allografts: bone grafts from a member of the same species. They can be mineralized. In principle, they are associated with osteoinductive and osteoconductive properties.
- Xenografts: bone grafts from other species with osteoconductive properties.
- Alloplastic materials: bone grafts of synthetic origin (hydroxyapatite, bioactive glass, tricalcium phosphate, etc). They have osteoconductive properties.

Among the various available techniques described, the objective of this article is to present a case report of preservation with an alloplastic material without the need for membrane.

**Case Report**

A female patient, 53 years of age, with no special medical history, presented for alveolar ridge preservation of tooth 47 for subsequent rehabilitation with implant. The patient had an endodontically-treated, infected and fractured tooth (Fig. 1-3). The chosen treatment was its extraction and, given the risk of placing an implant in such conditions, we decided to postpone it, preserving the alveolar ridge.

After the careful extraction of the tooth and without raising a flap (Fig. 4), we proceeded to a thorough curettage, irrigating the socket using 0.2% chlorhexidine. Once the socket was disinfected, we checked that the walls were intact and proceeded to fill it with the selected biomaterial.

In this case, we used a sterile resorbable beta-tricalcium phosphate material from Septodont (R.T.R.), presented in the form of 0.3 cm³ cones, made of beta tricalcium phosphate granules coated with a matrix of highly purified collagen fibers of bovine origin which, in the case of cavities that cannot be closed, prevents the granules from leaking out.

The cone was placed in the socket using clamps (Fig. 5, 6), waiting for it to be carefully impregnated with the patient’s own blood and compacting it (Fig. 7, 8). Finally, three crossed sutures were done on top, leaving the material slightly exposed.
and checking the final status by X-ray (Fig. 9, 10). As post-op instructions, the patient was instructed to rinse with 0.2% chlorhexidine mouthwash, three times a day, from the second day, and as medical treatment, amoxicillin 1 g 1 tab/8hr/7days and ibuprofen 600 mg 1 tab/8 hr/7 days were prescribed. After one week (Fig. 11), we removed the sutures and observed the start of healing of the soft tissues, also anticipating some maintenance of the alveolar ridge architecture, with less resorption than would occur spontaneously after simple removal of the molar.

Discussion

The case presented in this article correlates with previous studies in which, by using β-tricalcium phosphate and collagen bone grafts, it was possible to largely maintain the dimensions of the alveolar ridge.

In oral implantology, the goal of bone regeneration techniques is to increase or maintain bone volume for implant placement. Bone regeneration can be modified, by systemic factors, and also by using biomaterials or bone substitutes. Traditionally, the ideal material, considered as "gold standard" for bone regeneration has been the autologous bone, taken from the patient. However, in recent decades, new human, animal or synthetic materials have been introduced, such as beta-tricalcium phosphate (R.T.R.), which has been very successful in implantological surgical techniques in experimental studies. 5-14 Cardaropoli et al.15 and other studies16-18
showed that sites where preservation had previously been done presented less resorption at six months compared with areas without preservation. However, even having performed an alveolar ridge preservation, the crestal resorption in width was 17% to 25%.

On the other hand, it has also been studied that there is a little loss of crest height and width after preservation19, but even so, Lasella et al.20 concluded that the dimensions were improved, achieving conditions favorable for subsequent implant placement.

The alloplastic material used in this case is presented in the form of granules of beta tricalcium phosphate forming an osteoconductive micro- and macro-porous structure that encourages a dense growth of new bone.

The degree of bone regeneration from tricalcium phosphate varies depending on its formulation, porosity, and the size of the particles. The beta phase is more recommended because it is less soluble than the alpha phase. The dissolution rate of the material is related to its porosity, meaning that a greater porosity favors its resorption. In addition, the porosity is essential for perfusion, since the blood vessels and neoformed bone tissue need pores of at least 60 microns to grow. The size of the particles is also important since it has been shown that a smaller size causes less inflammatory reaction to a foreign body, which allows a stable mechanical interconnection and prevents phagocytic disintegration 21.

From a clinical viewpoint, the various studies that use β-tricalcium phosphate in oral implantology show that about six months can be considered as a bone healing period.22-31 The case reports in the literature show some successful results and provide clinical evidence to consider for future randomized and controlled clinical trials that more broadly study the benefits of this technique.

**Conclusion**

Alveolar ridge preservation is a technique that has shown to significantly reduce the bone resorption observed in the alveolar crest after tooth extraction, helping in the formation of hard tissue that is necessary for correct subsequent implant placement.

β-tricalcium phosphate (R.T.R.) has shown to be a good osteoconductive material for bone regeneration after filling a post-extraction socket, maintaining an adequate alveolar ridge for subsequent placement of a dental implant.

When β-tricalcium phosphate is gradually resorbed, it is replaced by bone similar to the original bone, obtaining a regenerated vital bone tissue. The cone presentation, in addition to adapting to the shape of the socket, does not need to be covered with a membrane, thus facilitating its placement and handling.
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Clinical case of alveolar ridge preservation with alloplastic material: Results at 6 months

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Introduction

The aim of this study is to demonstrate the results of treatment with dental implants placed after using bone filling biomaterial: beta-tricalcium phosphate (RTR bone grafting material - Septodont). As is known, when the absence of a tooth is to be restored through a dental implant after extraction, even though the implant is not placed immediately for a reason, e.g. infection in the dental alveolus, the alveolus is preserved to minimize bone resorption as far as possible. The postextraction resorption or bone loss mainly occurs in the vestibular wall. The measurements were made at 1.24 mm (vertical) and 3.79 mm (horizontal). Some authors estimate that 50% of the resorption volume occurs in the 12 months following the extraction and that two-thirds of this volume are lost in the first three months. The need to maintain hard and soft tissue means that it is crucial to avoid or minimize the bone resorption caused by the loss of a tooth.

Current studies indicate that, using the socket preservation technique, it is possible to reduce this loss of volume by around 1 mm vertically and around 3 mm horizontally. In the case shown here, the patient presented an infected alveolus due to failed endodontic treatment and irreparable fracture. Given the risk involved in placing an implant in these conditions, it was decided to carry out the procedure in a second session. In these cases, the preservation of the alveolus is highly recommended to avoid bone resorption as far as possible. From among the techniques available, we opted for filling with biomaterial of choice. The different steps taken are documented in a previous article. Once the regeneration period was over, we took a 3D image of the dental arch to plan the placement of the implant, which we describe below.
Clinical Case

The implants were placed six to nine months after the regenerative surgery following a surgical protocol similar to the one previously indicated for the extraction. The 53-year-old female patient was anaesthetized in the area, a crestal incision made (Fig. 1-4) with mucoperiosteal flap [total thickness] procedure without any vertical incisions. We visualised the appearance of the regenerated bone (Fig. 5) in line with the 3D image (Fig. 1-3) previously made and studied. We placed the two implants (Figs. 6-8) in accordance with the manufacturer's milling protocol (Straumann®). Finally, the flap was adapted by suturing and a post-operative image was taken (Fig. 9-10). The patient was advised to rinse with 0.5 chlorhexidine three times a day for 10 days, starting from the second day. As medical treatment, 1 g of amoxicillin every 8 hours for 7 days and 600 mg of Ibuprofen every 8 hours for days. The stitches were removed after 10 days. The patient was checked over three months, and the re-entry and placement of the healing abutments carried out to create the soft tissue and begin the prosthetic procedure.
Discussion

The dimensional changes in the alveolar ridge following a tooth extraction considerably compromise the functional and aesthetic results of restorations made in partially edentulous areas.

The restoration of isolated alveolar defects using implants, as is the case here, shows that bone regeneration through the use of beta-tricalcium phosphate is an option to be considered, both from the clinical point of view and from the patient’s perspective.

Following a healing period of between 6-9 months it was possible to place the implants without the need for any other regeneration procedure.4-7

Conclusion

The case presented indicates that beta-tricalcium phosphate (RTR bone grafting material - Septodont) can be used successfully for bone regeneration in dental implant treatment.

One of the main advantages of this technique is the elimination of the inevitable morbidity and problems associated with autologous bone graft, both in the intraoral and the extraoral areas.8-11

The patient’s opinion on the treatment was very positive, both on the process itself and on the appearance achieved, and on the functioning observed after 12 months of monitoring.

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Use of β-tricalcium phosphate for alveolar preservation; a report on a series of cases.

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Summary

β-tricalcium phosphate is a high purity material that helps to safely generate bone neoformation after tissue extraction or loss. Preservation treatment was performed using a β-tricalcium phosphate cone (R.T.R Cone, Septodont, France) in the lower right quadrant, at the lower third molar area (tooth 48), for research purposes; it was kept under observation for periods of 1 week, 1 month and 3 months. In the quadrant with the R.T.R, favorable bone neoformation process was observed in a shorter time compared to the left quadrant, and a progressive and total reabsorption of the R.T.R was observed after 3 months. The use of β-tricalcium phosphate is a useful alternative for post-extraction alveolar preservation, improving the speed of bone regeneration.

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Introduction

Bone regeneration with alveolar preservation following tooth extraction has been a topic of major significance recently due to the use of dental implants as a method of esthetic and functional rehabilitation; the improvement of regeneration time is therefore a significant issue, and for such purpose alveolar preservation techniques using various materials have been proposed (hard and soft tissue grafts) in view of maximizing tissue preservation and minimizing defects. β-tricalcium phosphate (β-TCP) is a synthetic ceramic bone graft material that has been in use in medicine and dentistry for more than 30 years, in the fields of orthopedics, periodontology and maxillofacial surgery. Pore size varies from 5 to 500 μm, and the porosity ranges from 20 to 90% depending on particle size. For dental use, particle size is generally less than 100 μm. Used as a graft material, β-TCP stands in for the mechanism of osteoconduction; when it is used in the biological process, the material is reabsorbed and replaced by the recipient’s own bone. The interconnection between pores facilitates osteoconduction. When the graft is placed at the receptor site, some serum proteins are absorbed and retained on the surface of the particles, contributing to the subsequent cellular migration that will stimulate a neovascularization process in the porous structure. The R.T.R. (Resorbable Tissue Replacement), is composed of β-tricalcium phosphate, a material used for alveolar preservation after a tooth removal when posterior prosthetic rehabilitation is planned. The objective of the following series of clinical cases was to evaluate the alveolar preservation achieved with the use of R.T.R cones and without the use of R.T.R by radiographic evaluations at three-month follow-up. Case reporting was conducted in compliance with Case Report Guidelines (CARE).

Report on a series of cases

Four patients were selected to conduct alveolar preservation with the use of β-tricalcium phosphate (R.T.R) cones; these patients were required to meet certain criteria. The inclusion criteria used for this report were: patients of both sexes, retained third molars Pell & Gregory class I and II subdivision A and B, bilateral, age range between 18 and 22 years, no periodontal or periapical disease in the lower molar region, and willingness to perform the alveolar preservation procedure for research purposes. The exclusion criteria used for this report were: patients with uncontrolled systemic diseases, acute infectious processes, pregnant or lactating patients, patients with bone diseases, use of bisphosphonates, and poor oral hygiene. Patients meeting the admission criteria for the clinics and oral surgery department of the “Escuela Nacional de Estudios Superiores”, of the UNAM, León Unit, were evaluated.

Auxiliary diagnostic studies were performed (Panoramic radiographs, Periapical views), and no disorders being found in any patient, a diagnosis was made in the full series of cases; retained third molars Pell & Gregory class I and II, subdivision A and B, bilateral.

The patients signed informed consent forms in which they are made aware of the diagnosis, treatment plan and possible complications during treatment.
PATIENT 1

Fig. 1: Extraoral photographs (A: frontal B: lateral)

Fig. 2: Intraoral photographs (A: right side B: top C: left side D: bottom)

PATIENT 2

Fig. 3: Extraoral photographs (A: frontal B: lateral)

Fig. 4: Intraoral photographs (A: right side B: top C: left side D: bottom)

PATIENT 3

Fig. 5: Extraoral photographs (A: frontal B: lateral)

Fig. 6: Intraoral photographs (A: right side B: top C: left side D: bottom)
PATIENT 4

Surgical odontectomies of teeth 38 and 48 were performed under local anesthesia by infiltration with lidocaine and epinephrin 2%, 1:100,000; a Newman’s incision was performed, the muco-periosteal flap lifted, osteotomy and odontectomy conducted, the cavity washed, and a cone of β-tricalcium phosphate (R.T.R) placed in the residual alveolus of tooth 48; on the opposite side the lower left quadrant in the area of tooth 38 was left with nothing placed inside the alveolus, and both sides were sutured using polyglactin 910 4/0; postoperative management with Amoxicillin 500 mg, 1 every 8 hours for 5 days, and Ibuprofen 400 mg, 1 every 8 hours for 3 days; instructions for general postoperative measures were likewise provided.
Fig. 13: Surgical procedure
(A) Anesthesia, (B) Incision, (C) Preparation of the flap, (D) Osteotomy, (E) Luxation, (F) Extraction, (G) Extraction sample, (H) Residual Alveolus, (I) Septodont ß-tricalcium phosphate, (J) ß-tricalcium phosphate Cone, (K) ß-tricalcium phosphate Cone transport, (L) Application of ß-tricalcium phosphate Cone, (M) Syneresis.

Patients were evaluated 7 days after surgery; good evolution was observed, with an adequate healing process underway; radiographically, a mixed image was observed (black and white radiographic image), interpreted as the ß-tricalcium phosphate cone (R.T.R) in tooth 48, and a radiolucent image was observed in tooth 38, corresponding to the residual alveolus; after a month of evolution, we were able to observe improved healing. The area treated with R.T.R showed larger areas of radiopacity, interpreted as improved bone neoformation compared to the
residual alveolar process area at tooth 38, where slower bone formation was observed, considering the greater areas of radiolucency. The third month of observation allowed us to verify the presence of improved bone regeneration, a radiopaque image of the residual alveolus at tooth 48, in addition to total reabsorption of the material, as indicated by the manufacturer, and reduced bone trabeculation compared to the residual alveolar process area at tooth 38.

Fig. 14: Control periapical radiograph patient 1

Fig. 15: Control periapical radiograph patient 2

Fig. 16: Control periapical radiograph patient 3

Fig. 17: Control periapical radiograph patient 4
Classically, the ideal material considered for bone regeneration has been autologous bone. However, in recent decades new materials of human, animal or synthetic origin have been incorporated into the arsenal, which have revolutionized alveolar preservation techniques.\(^4\)

The action of $\beta$-tricalcium phosphate (R.T.R) on alveolar preservation, in comparison to the natural bone healing process, has been proven.\(^5\) As for its regeneration mechanism, $\beta$-tricalcium phosphate (R.T.R) is a biocompatible material that would seem to have scaffold action permitting osteoblasts to grow on its surface and invade its structure.\(^6\)

It has proved to be an excellent biomaterial with high success in bringing about the bone regeneration necessary to maintain adequate space for implant insertion.\(^6\)

When the $\beta$-tricalcium phosphate is reabsorbed, it is replaced by bone that is anatomically and functionally similar to the original bone, thus producing regenerated vital bone tissue, which means that this bone remodeling and maturation process, necessary for the functional loading of implants, is not disturbed by the material.\(^7\) Residual elements may occasionally remain, which can be demonstrated clinically and radiologically after 6 months.\(^8\)

The overall results of the study showed that at clinical follow-up, 1 year after the functional loading of implants (6 months after surgery), no failures were observed in either the implants or the various different implant-supported prosthetic options.\(^9\)

In light of the case reports discussed above it was thus observed that after 3 months of observation the time of bone neoformation was significantly improved where R.T.R was used, as compared to the residual alveolar process where no alloplastic material had been placed; R.T.R is thus a choice material for the effective post-odontectomy preservation of alveolar bone.

**Discussion**

**Conclusion**
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She has participated as a national and international lecturer in conferences, courses and congresses in the area of Maxillofacial Surgery, with topics such as Orthognathic Surgery, Dentoalveolar Surgery, Implantology, Craniomandibular Dysfunction, Tissue Regeneration and Regenerative Medicine among others.

Currently, she is responsible for projects PAPIME (Project Support Program for Innovation and Improvement of Teaching), Multi-centric and International Research Projects and joint projects with the area of Biomedical Engineering of the Autonomous University of Aguascalientes and develops research projects in the area of Craniomandibular Dysfunction and Regenerative Medicine.
References


We have not found in the international literature any study regarding the use of \( \beta \)-TCP in the treatment of infrabony pockets in young patients with aggressive periodontitis, which are a clinical entity that very rapidly results in the destruction of alveolar bone with tooth morbidity as a consequence. For this reason the objective of this study is to evaluate and analyse the action of \( \beta \)-TCP (R.T.R.) on infrabony lesions in young patients suffering from aggressive periodontitis.

**Introduction**

Aggressive periodontitis, a clinical case frequent in the Maghreb, represents the most destructive form of periodontal diseases which results in bone lysis, dental mobility and then loss of teeth. Their appearance starts early in life causing aesthetic and functional damage.

These diseases are characterised by an anaerobic Gram negative flora. There are two classes:
- The form localised in the incisors and the first molars, as shown clinically in Figure 1 and with X-ray in Figure 2.

![Fig. 1: Clinical aspect](image1)

![Fig. 2: Notice the terminal lysis at the level of 21](image2)
We perform on each patient a clinical, radiological and bacteriological examination followed by a surgical treatment consisting in flap surgery combined with R.T.R. grafting material (syringe). The clinical evaluation consisted in measuring the depth of the pockets. The X-ray examination allowed the evaluation of the bone level of our patients thanks to the retroalveolar - panoramic and radiovisiography images. The bacteriological evaluation consisted in subgingival specimens and fresh bacterial profile study, Gram staining, culture and PCR. The therapeutic schedule consisted in:

• Initial therapy (scaling and root planing)
• A systemic anti-infectious therapy with amoxicillin 1 g/d and metronidazole 600 to 800 mg/d over 10 days.
• A surgical therapy combining flap surgery and insertion of R.T.R.
• The surgical sequence is the following:
  - Anaesthesia
  - Incisions
  - Careful debridement
  - Elimination of granulation tissue
  - Scaling and root planing
  - In situ placement of R.T.R. using the syringe presentation
  - Sutures
  - Placement of surgical pack
  - A maintenance phase with clinical and radiography re-assessments over four years

Materials & methods

We perform on each patient a clinical, radiological and bacteriological examination followed by a surgical treatment consisting in flap surgery combined with R.T.R. grafting material (syringe). The clinical evaluation consisted in measuring the depth of the pockets. The X-ray examination allowed the evaluation of the bone level of our patients thanks to the retroalveolar - panoramic and radiovisiography images. The bacteriological evaluation consisted in subgingival specimens and fresh bacterial profile study, Gram staining, culture and PCR. The therapeutic schedule consisted in:

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  - Anaesthesia
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  - Elimination of granulation tissue
  - Scaling and root planing
  - In situ placement of R.T.R. using the syringe presentation
  - Sutures
  - Placement of surgical pack
  - A maintenance phase with clinical and radiography re-assessments over four years

Case series

4 patients were chosen for whom five sites were treated:
• 2 upper sites (16-21)
• 3 lower sites (36-46-46)

- The first patient presented a generalised aggressive periodontitis with a severe intrabony defect at 21 associated with an extrusion and at the level of 16 a terminal bone lysis with a pocket depth of 9 mm.
- The second patient suffered from generalised aggressive periodontitis with class 3 bifurcation involvement at the level of 46 as well as mesial and distal pocket depth of 7 to 5 mm.
- The third patient, 17 years old, with localised aggressive periodontitis and mesial infrabony lesions with a pocket depth of 8 mm.
- The fourth patient, 16 years old, with a localised aggressive periodontitis, presented 5 mm pockets distally at the level of 46.
A 19-year-old woman presented with severe generalised aggressive periodontitis. On a clinical level, this patient presented an inflammatory condition of the maxillary and mandibular gum with migration of 21 (Fig. 5).

On a radiographic level, the panoramic X-ray of the maxillary showed infrabony lesions (Fig. 6) with deep lysis at the level of 21 and terminal lysis at the level of 16 (Fig. 7).

It was decided to treat 21 and 16 given the situation of these severe lesions.

The therapeutic schedule adopted is the following at the level of 21.

T0
- Etiological therapy + amoxicillin + metronidazole antibiotic therapy
- Surgical phase: flap + bone substitute: R.T.R. (Fig. 8 & 9)

T 1 year
- Clinical and X-ray reassessment. On the X-ray, filling of infrabony lesion with 25% bone gain. (Fig. 10)
- At this stage the migration treatment was performed.
- Orthodontic treatment phase due to migration of 21 (Fig. 11)

A stabilisation of the bone gain after initiation of orthodontic treatment was observed (Fig. 12)

The reassessment of the infrabony lesion at 4 years by radiovisiography showed a bone gain of 50% (Fig. 13). A definitive fixation was performed.
The study of the posterior site (16) in the same patient showed:
- On a clinical level, the probing detected pocket depths of 9 to 11 mm (Fig. 14).
- On the X-ray, a terminal bone lysis (Fig. 15).

The therapeutic schedule of the infrabony lesion of 16 is the following:
- Etiological therapy
- Surgical phase: mucoperiosteal flap associated with in situ placement of R.T.R.
  The surgical treatment sequence:
  - Incision and raising of the flap (Fig. 16)
  - Debridement of lesion
  - Elimination of granulation tissue
  - Polishing and planing of root
  - Insertion of R.T.R. using the syringe: the granules are mixed with a few drops of blood (Fig. 17)
  - Sutures
  - Surgical pack (Fig. 18)
  - Placement of surgical pack

The reassessment at 1 year shows the filling of the infrabony lesion (Fig. 19).
At 4 years it shows a 50% bone gain (Fig. 20).
**Case Report no.2**

A 18-year-old patient presented with severe generalised aggressive periodontitis (Fig. 21). The panoramic x-ray showed at the level of 46: Infrabony lesion + bifurcation involvement and depth of pockets of 7 mm (Fig. 22).

Clinical aspect before surgery (Fig. 23).
Placement of R.T.R. (Fig. 24).

The radiography X-ray shows an infrabony lesion associated with a class 3 bifurcation involvement (Fig. 25). At 15 days the filling material is in place (Fig. 26).

At 4 years the reduction in the pocket depth is of 4 mm, we noticed the absence of bifurcation involvement (Fig. 27).

**Case Report no.3**

A 17-year-old patient presented with localised aggressive periodontitis (Fig. 28) with an average pocket depth of 8 mm and mesial infrabony lesion of 36 (Fig. 29).

The therapeutic schedule is the following:
- Etiological therapy associated with medical treatment which consisted in a combination of amoxicillin and metronidazole during 10 days
- Surgical treatment: incision (Fig. 30), raising of the flap, placement of the bone substitute (Fig. 31).

The results at 1 year (Fig. 32) and at 4 years (Fig. 33) are very satisfactory.
Case Report no.4

The 16-year-old patient presented with inflammatory gum condition (Fig. 34). In the X-ray, we observed prior to treatment an infrabony defect of 46 with a pocket depth of 5 mm and 25% bone loss (Fig. 35).

For this patient, it was decided to follow the same therapeutical protocol as previously described.

At 4 years we see the filling of the infrabony lesion with an absence of periodontal pocket and a normal aspect of the desmodontal space (Fig. 36).

Discussion

The use of R.T.R. (β-TCP) allowed:
- A reduction in the depth of pockets and an attachment gain.
- A decrease in the dental mobility index.
- The panoramic and the visiography X-rays showed a bone gain with filling of infrabony lesions.
- Modifications of the bacterial biofilm in numerous studies (Haffajee and al.) show that certain species of the red complex (Tannerella forsythus, Treponema denticola) and of the orange complex (Prevotella intermedia, Campylobacter rectus) can evolve differently. Depending on the surgical debridement, these species can recolonise the sites in a very delayed manner due to the decrease in their toxic potential and the modification of their tissue environment.
  We thus observed in our patients a decrease in bacteria such as Tannerella forsythus, Prevotella intermedia, Porphyromona gingivalis Aggregatibacter actinomycetemcomitans, Treponema denticola at 1 year and 4 years. The flap combined with the filling would be in favour of the restoration of the epithelial barrier at the bottom of the pocket with an almost absence of the available nutrients essential for the red and orange complex bacteria.
- The bone gain obtained would be related to the use of phosphocalcium derivative bioactive materials which increase bone formation.
Conclusion

Our work demonstrates that an advanced aggressive periodontitis with the presence of terminal lysis could be currently treated whereas about fifteen years ago tooth extraction was the only alternative.

A significant improvement of the depth of the pockets, attachment level, decrease in dental mobility, modification of subgingival bacterial biofilm and bone gain are the results obtained at 4 years.

The success of our therapy would not have been possible without fighting against the bacterial biofilm, or without the full cooperation and consent of our patients.

These diseases constitute a public health problem due to the speed and severity of their evolution with functional consequences and psychosocial repercussions related to the early loss of teeth. This technique has given excellent results in young subjects.

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Introduction

The effects of periodontal infection and its consequences, attachment and bone losses, result in the formation of periodontal bone defects (1,2). Tooth extraction involves two processes, the healing of the alveolus (3) and any change that may appear during post-extraction healing (4). The clinical consequences of tooth extraction are the resorption of the alveolar ridge (5) and the pneumatization of the maxillary sinus (6). If the effects of periodontal disease and tooth extraction are combined, the consequences will be even more severe and will complicate tooth restoration (7). The use of bone grafting materials prevents and/or repairs the insufficient bone conditions due to the previously mentioned situations (8). We will first evaluate the biological characteristics (9) of the alloplastic graft material, beta-tricalcium phosphate, before presenting Clinical Cases using a commercial presentation of beta-tricalcium phosphate. The objective of this presentation is to demonstrate the clinical applications of beta-tricalcium phosphate alloplastic graft in periodontal bone defects and extraction sites.

Modifications in the Alveolar Process

The most common modifications involving the bone tissue of the oral cavity are: Horizontal bone loss due to periodontal infection, bone defects caused by periodontal disease, tooth extraction resulting in vertical and horizontal
resorption, pneumatization of the maxillary sinus and a combination of these. The clinical consequence of these conditions are inappropriate bone dimensions for prosthetics on natural abutment teeth and the placement of its substitutes, dental implants (10).

**Periodontal bone defects**

As a result of inflammatory and immune reactions to the presence of bacterial plaque and the way in which it progresses apically over the cement surface in one of the periodontal attachment components, the alveolar bone, specific patterns of destruction can be observed. These patterns depend mainly on the type of subgingival bacterial plaque and the anatomical characteristics of the alveolar process (11). Basically there are two bone loss patterns, horizontal or vertical forms. The vertical form of bone loss has been described as intrabony loss and the resulting defects have been historically classified according to the number of bone walls lost: one, two or three-wall intrabony defects. Other bone loss patterns have been described as osseous craters and circumferential defects. The special anatomy of molars and premolars involves furcations as a special condition in periodontal defect (12).

**Tooth extraction**

The consequences of tooth extraction represent specific conditions and a special challenge in conventional restorative dentistry and oral rehabilitation, especially with the use of dental implants (13). Whether in case of single or multiple implants - as abutments for fixed bridges and/or removable prosthesis – or in complete oral rehabilitation, the bone loss that follows tooth extraction in alveolar area or in edentulous arch represents a clinical challenge (14). The consequences of this biological process are both functional - which complicates the prosthesis design - and aesthetic, especially in the anterior zone. After tooth extraction, the alveolus has a very high and predictable chance of healing in a natural and healthy way without any intervention. The biological principle of the alveolus repair is based on the formation of a blood clot that covers it completely. Post-extraction healing process has been accurately described. The stages of this natural process may be summarised in the following manner: At 30 minutes: clot; at 24 hours: formation of blood clot and haemolysis; at 2-3 days: formation of granulation tissue. At 4 days: increase in fibroblast density and epithelial proliferation over the edge of the wound and presence of osteoclasts indicating the alveolus remodelling. At 1 week: defined vascular network and maturing connective tissue; osteoid formation in the bottom of the alveolus. At 3 weeks: dense connective tissue; full epithelial cover. At 2 months: full bone formation is complete but without reaching the original height (15,16).

**Graft Material Characteristics**

Autogenous bone is the only graft material that meets the requirement of being osteogenic activating new bone formation via viable osteogenic cells (Periostium osteoblasts, endostium, bone marrow cells, perivascular cells and undifferentiated and/or stem cells) which are transplanted with the material and is considered as the “Gold Standard” as it also has osteoinductive and osteoconductive properties (17,18). The term “Osteoinduction” implies the biological effect of inducing differentiation of pluripotent undifferentiated cells and/or potentially inducible cells to express the osteoblast phenotype leading to new bone growth both within bone tissue and in ectopic sites. i.e. sites in which there is no natural bone formation. Even though there are several molecules able of inducing “de novo” bone tissue formation, the Bone Morphogenetic Protein (BMP) is the main protein involved (19). The term “Osteoconduction” refers to the characteristic of the graft material to act as a scaffold or mesh on which existing bone cells can proliferate and form new bone. In the absence of this supporting structure
provided by the material, the defect or bone surface would be filled or covered by fibrous soft tissue. The porosity, pore size, shape, particle size and physical/chemical characteristics influence the biological effects of cell adhesion, migration, differentiation and vascularisation at the receptor site (20,21).

**Classification of graft materials by origin**

Autogenous materials or Autografts are tissues from the same individual transplanted from one site to another. Viable cortical or spongy/medullar bone is commonly used in periodontology and maxillofacial surgery. Allogenic materials or Allografts are tissue from one individual of the same species; usually via a freeze-drying process; bone and skin are the most common ones. Xenografts are tissue from different species; mainly mineral bone component or collagen. Alloplastic graft materials are synthetic materials, i.e. they are manufactured by industrial processes and the most representative in medical dental use are Hydroxyapatite, ß-Tricalcium Phosphate and Bioactive glasses or polymers (22).

**Beta-tricalcium phosphate**

Beta-tricalcium phosphate (β-TCP) is a synthetic ceramic bone graft material which has been used in orthopaedic and dentistry -periodontology and maxillo-facial surgery - for more than 30 years (23). ß-TCP can be treated during the manufacturing process so that it has a structure similar to the bone mineral component, either in a block or in particles similar to spongy or trabecular bone (24). This structure has randomly interconnected pores. Porosity may range from 20% to 90%. The variation in pore size ranges from 5µm to 500µm depending on the particle size. The particle size in dental use is generally inferior to 1000µm. The mechanism of action of ß-TCP as a graft material is via osteoconduction with the subsequent resorption and replacement by host bone. (25) Osteoconduction is facilitated by the interconnection between pores. In the biological process the material is resorbed and replaced by bone from the receptor individual. When the graft is placed in the receptor site, serum proteins are adsorbed on the surface of the particles, which later favours cell migration to initiate neo-vascularisation in the porous structure. Over time, the particles inferior to 1 micron start to dissolve and are then resorbed in a process mediated by phagocytic cells, thus allowing bone deposit over the material. The level of porosity and the particle size will define the resorption rate and the bone replacement process which occurs in 9 to 12 months in average (26).

**Case Report no.1**

48-years-old male patient in general good health conditions with two localized areas presenting some discomfort since a couple of months mainly in tooth 15 where the patient refers recurrent swelling but without need to take analgesics. A full periodontal examination reveals a localized distal periodontal probing of 10 mm. with bleeding and suppuration and a mild redness *(Fig. 1)*.

*Fig. 1: Bleeding and suppuration in 10 mm pocket in tooth 15*
On X-ray examination a wide distal intrabony-two walls defect is present(Fig. 2). The previous root canal treatment seems without complications in the periapical area. The localized periodontal attachment loss and the overall periodontal health could support the etiology of pulpar complication i.e. a lateral canal since the patient report at least 8 years of root canal treatment after a painfull episode in the tooth.

A flap debridement procedure is indicated and it is confirmed the bone defect and irregular bone loss in the vestibular cortical plate. (Fig. 3).

With the pulpar involvement as main etiology an effort is done to find clinical evidence i.e. localized area of resorption and/or lateral foramen without confirmation. It is decided to use β-tricalcium phosphate “R.T.R.” (Septodont) as a graft material. (Fig. 4).

Fig. 2: Initial X-ray showing the intrabony-two walls defect.

Fig. 3: After debridement, scaling and root planning a complicated bone loss is present.

Fig. 4: β-tricalcium phosphate “R.T.R.” (Septodont) as a graft material.

Fig. 5: X-ray taken immediately after the surgical procedure showing the particles of β-tricalcium phosphate “R.T.R.” (Septodont) in the defect.

Fig. 6: X-ray six months post-surgery where the particules of β-tricalcium phosphate “R.T.R.” (Septodont) has been replaced with recently formed trabecular bone and the bone defect appears with some lateral reduction.
Case Report no.2

A second problem is identified at the periodontal examination in tooth 46 and confirmed with the X-ray. An extensive root resorption on the distal root is present (Fig. 7) with any symptom reported by the patient except some discomfort and “bad taste” occasionally. The root canal treatment was done at the same time than tooth 15 (eight years before). The clinical condition makes difficult to try endodontic retreatment or other treatment options like hemisection, the extraction is indicated. In order to avoid the collapse of the residual alveolar bone and the socket, particles of β-tricalcium phosphate “R.T.R.” (Septodont) is used as graft material. (Fig. 8,9).

Conclusion

In concepts of Osteogenesis, remains today still open the debate as to which type of currently available bone grafting material is the best.

Fig. 7: X-ray showing extensive root resorption on the distal root of tooth 46.
Fig. 8: Clinical view showing the extensive bone loss in the residual ridge after the tooth extraction. Notice the minimal width at the crestal area in the buccal and lingual plates and the attachment loss at the mesial root of tooth 47.
Fig. 9: Composite blood clot and β-tricalcium phosphate “R.T.R.” (Septodont) used as graft material prior the suture. In the area of resorption a cone shaped β-tricalcium phosphate “R.T.R.” (Septodont) is used and in the mesial root alveolus particles of β-tricalcium phosphate “R.T.R.” (Septodont) are used.

Fig. 10: X-ray taken immediately after the surgical procedure showing β-tricalcium phosphate “R.T.R.” (Septodont) in the bone defect and mesial root alveoli.
Fig. 11: 6 months of clinical healing.
Fig. 12: X-ray 6 months post-surgery where the particles of β-tricalcium phosphate “R.T.R.” (Septodont) have been replaced by recently formed trabecular bone in the bone defect and mesial root alveolar.
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The inflammatory response as a result of periodontal infection leads to the loss of tooth support tissues\(^1\). The alveolar bone and its three components, cortical plates, trabecular bone and bundle bone (alveolar bone proper), are lost through periodontal infection\(^2\). Other conditions can worsen the periodontal condition, mainly endodontic, prosthetic and traumatic complications\(^3,4,5\). When the tooth extraction is indicated, the anatomic characteristics of the alveolus, the associated lesion and phenotype of the periodontal tissues can lead to a healing of the alveolar ridge with an inadequate morphology to the replacement of the lost tooth with fixed/removable prosthetics and/or dental implants\(^6,7,8\). Restoration of adequate conditions in the periodontium destroyed by periodontal infection to preserve the dentition in health and function\(^9,10\), and/or maximizing the healing conditions in the alveolar ridge post extraction for prosthetic restoration\(^11,12\), is indicated with the use of graft materials. It provides predictable results, safe use and no availability restrictions. These characteristics are present in the synthetic bone graft substitute R.T.R. (beta tricalcium phosphate)\(^13,14,15,16\).
Clinical Cases

62-year-old patient with recurrent periodontal disease without infection control after a previous treatment in February 2007. The main concern is “I do not want to lose my teeth”. The clinical aspect shows high plaque score, signs of inflammation, bleeding on probing, periodontal attachment lost and, radiographically, bone lost, pathologic migration and inadequate occlusal relations (figs. 1,2). At the beginning of the retreatment the patient was instructed about the problem with emphasis on infection control by meticulous daily plaque control and oral home care. Once the change in attitude and compromise were noted, the treatment plan was initiated.

Diagnosis
Chronic generalized periodontal disease with advanced periodontal attachment lost.

Treatment plan
Flap debridement and scaling and root planing in superior arch and scaling and root planing alone in lower arch. Prognosis in the anterosuperior segment is reserved.

Procedure description
Anterosuperior segment. Flap debridement and scaling and root planing filling the osseous defects with bone graft substitute, R.T.R, and collagen membrane (Figs. 3,4).
Healing
The initial radiographs show bone loss and, in radiographs 10 months later, the bone-fill in the defects is evident (Fig. 5). Initial clinical view and healing (Fig. 6).

In the lower right quadrant, extraction of tooth 46 is depicted. The distal alveolus and bone defect with loss of the vestibular plate was filled with bone graft substitute, R.T.R. cones. The blood clot covers the intact alveolus of the mesial root (Fig. 7).

Figure 9 shows the complete osseous filling of the osseous defect and the compromised socket post extraction at the time of the implant surgery with bone regeneration at 9 months, and radiographic evidence.
Conclusion

Loss of periodontal attachment and the consequent alveolar bone destruction resulting from the periodontal infection require procedures to provide periodontal regeneration. This goal requires an accurate diagnosis of the condition and high practitioner skills. Predictability is restricted to certain situations. The loss of the bone morphology in the residual ridge post extraction is worse if combined with periodontal attachment loss, extraction procedure complications, periapical lesions and/or traumatic events. Prevention and improvement of the healing post extraction is a common procedure with restorative, prosthetic and implant dentistry. The use of a bone substitute graft material like beta tricalcium phosphate (R.T.R., Septodont) ensures biologically secure procedures, predictability in results and total availability. The clinical results are adequate and scientific evidence-based.

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References

Sinus Floor Augmentation with β-Tricalcium Phosphate (R.T.R. Septodont)

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Resorption of the alveolar process and pneumatization of sinus in the edentulous posterior maxilla are a clinical challenge in the restorative/prosthetic treatment with dental implants. Diverse surgical procedures, bone grafts and substitutes have been used to repair that clinical situations. Reports have shown radiographic, histomorphometric and clinical significant results with β-Tricalcium Phosphate. Two clinical cases of sinus floor augmentation with β-Tricalcium Phosphate (R.T.R. Septodont) or the subsequent insertion of dental implant are presented in this report.

History

Resorption of the alveolar process and the pneumatization of the sinus in the posterior edentulous maxilla often represents a clinical challenge in restorative/prosthetic treatment with dental implants (1). Al-Nawas and Schiegnitz (2014), continuing the work of Klein (3), have proposed a classification of augmentation procedures in which graft materials are used for bone formation in therapy with dental implants:

1) Maxillary sinus floor augmentation, including the lateral window technique and transalveolar approach and, 2) vertical and/or lateral alveolar ridge augmentation, including dehiscence-type and/or fenestration-type defect around the implant (2).

The biological and physiological properties of the bone grafts and bone substitute materials (BSM) have been described in terms of osteoinductivity, osteoconductivity and osteogenicity. Osteoconductivity can be described in terms of a biocompatible scaffold, resorbable at different speeds and time, in which the material reacts without consequences with the tissues at the receptor site. The three-dimensional structure of the material mostly facilitates vascular proliferation and, soon after, colonization and growth of osteoprogenitor and osteogenic cells. The physical and chemical properties influence bone formation to a lesser degree (4).

Tricalcium Phosphate

With a composition and crystallinity similar to the mineral phase of bone, Tricalcium Phosphate (Ca3(PO4)2) is a biocompatible and bioresorbable material. Biodegradation of the material occurs in two ways: dissolution and osteoclastic resorp-
Animal models have shown the resorption of beta-TCP, its replacement by bone and formation of bone marrow. Particle size, microporosity and speed of resorption confer its osteoconductive properties and promote the bone formation process. Placed directly in cancellous bone, it retains its osteoconductive properties, and no tissue or systemic reactions were reported. Osteoconductive properties have been reported at ectopic sites. For decades, it has been used in Orthopaedics and multiple dental applications.

Procedure for maxillary sinus floor elevation

Two authors developed the surgical technique to augment bone height from the base of the maxillary floor. Various modifications have been reported in the literature, but retaining the initial proposal: increasing the vertical dimension from the maxillary sinus floor with the use of graft and/or bone substitute materials placed between detached epithelial membrane and the denuded bone. The use of bone substitute materials has been reported in maxillary sinus floor augmentation procedures, including beta-tricalcium phosphate, with histomorphometric analysis and simplified techniques. Trombelli et al. report the results of transcrestal maxillary sinus floor elevation done with a minimally invasive procedure and combined with the additional use of deproteinized bovine bone mineral or beta-tricalcium phosphate. The survival of dental implants in maxillary sinus floor augmentation procedures with beta-tricalcium phosphate has been reported. The authors report an increase in bone quantity associated with a decrease in grafted material and the presence of osteoclasts around the remaining particles of material. No complications or loss of implants were reported at 12 months.

Case Report no.1

Female patient, 56 years of age

Fig. 1: Edentulous area, first quadrant. Absence of premolars and molars lost 12 years ago. Replaced with removable partial denture.

Fig. 2: Occlusal view, quadrant 1.

Fig. 3: Maxillary sinus floor augmentation procedure with lateral approach and beta-tricalcium Phosphate "R.T.R." Septodont with bone graft substitute material (day 0).

Fig. 4: Pre-op X-ray (day 0).
Fig. 5: X-ray immediately post-op showing the location of the ß-Tricalcium Phosphate on the maxillary sinus floor -radiolucent area- (day 0).

Fig. 6: X-ray six months after the maxillary sinus floor augmentation procedure with lateral approach and ß-Tricalcium Phosphate “R.T.R.” Septodont as bone graft substitute material. The decrease in the radiolucent area shown in Fig. 6 is obvious, indicating the replacement of the material with new bone.

Fig. 7: During the surgical procedure (at 7 months) of implant placement, at the site of 14, the presence of the vestibular cortical plate of inadequate thickness is noted.

Fig. 8: ß-Tricalcium Phosphate “R.T.R.” Septodont as bone graft substitute material in the vestibular plate of 14. Distal implant in the first molar area placed in the area of the maxillary sinus floor augmented 7 months earlier.

Fig. 9: X-ray immediately after placement of the prosthetic pillars on the implants. Stability of the implant in the area of 16 was clinically proven.

Fig. 10: Prosthetic restoration 10 months after the maxillary sinus floor augmentation procedure with lateral approach and ß-Tricalcium Phosphate “R.T.R.” Septodont and 3 months after placement of the implants.
Case Report no.2

Female patient, 55 years of age

Fig. 1: Left atrophic posterior maxilla. Absence of molars lost approx. 10 years ago. Replaced with removable partial denture.

Fig. 2: Occlusal view of the area.

Fig. 3: Pre-op X-ray.

Fig. 4: X-ray immediately post-op showing the placement of the β-Tricalcium Phosphate on the maxillary sinus floor -radiolucent area- (day 0).

Fig. 5: Pre-op clinical image 6 months after β-Tricalcium Phosphate graft “R.T.R.” Septodont.

Fig. 6: In the window of the sinus lift procedure done 6 months earlier, granules of β-Tricalcium Phosphate “R.T.R.” Septodont are observed, which indicates partial replacement with new bone.
Fig. 7: X-ray image to confirm the cutting depth (2.5 mmØ) of the implant receptor site at 10 mm (arrow). Partial replacement of the bone substitute material with receptor bone is obvious.

Fig. 8: With osteotomes (Summers technique, 1994) the maxillary sinus floor is lifted 2 mm to achieve insertion of a 12-mm long implant.

Fig. 9: Implant 12 mm long by 5 mm diameter placed at bone crest level.

Fig. 10: X-ray image showing the placement of the implant.

Conclusions

Resorption of the alveolar process and pneumatization of the sinus in the edentulous posterior maxilla often represents a clinical challenge in restorative/prosthetic treatment with dental implants (1). Various surgical procedures and graft materials have been used to correct such changes (20-22), including β-Tricalcium Phosphate (23). Miyamoto et al. report “… particles of tricalcium phosphate attract osteoprogenitor cells that migrate into the interconnected micropores of the bone substitute material by six months” (25). The stability of the implants placed at the sites has been evaluated (24). A recent systematic review concludes: “There is a high level of evidence that survival rates of dental implants placed into augmented areas are comparable with survival rates of implants placed in pristine bone. For maxillary sinus floor elevation, all investigated bone substitute materials performed equally well compared with bone, with high dental implant survival rates and adequate histomorphometric data” (3). The two cases presented show satisfactory results in the use of the bone graft material, β-Tricalcium phosphate “R.T.R.” Septodont based on the evidence reported. This, along with the availability of the material and its safety in use, make it a therapeutic choice with multiple benefits.
References


References
