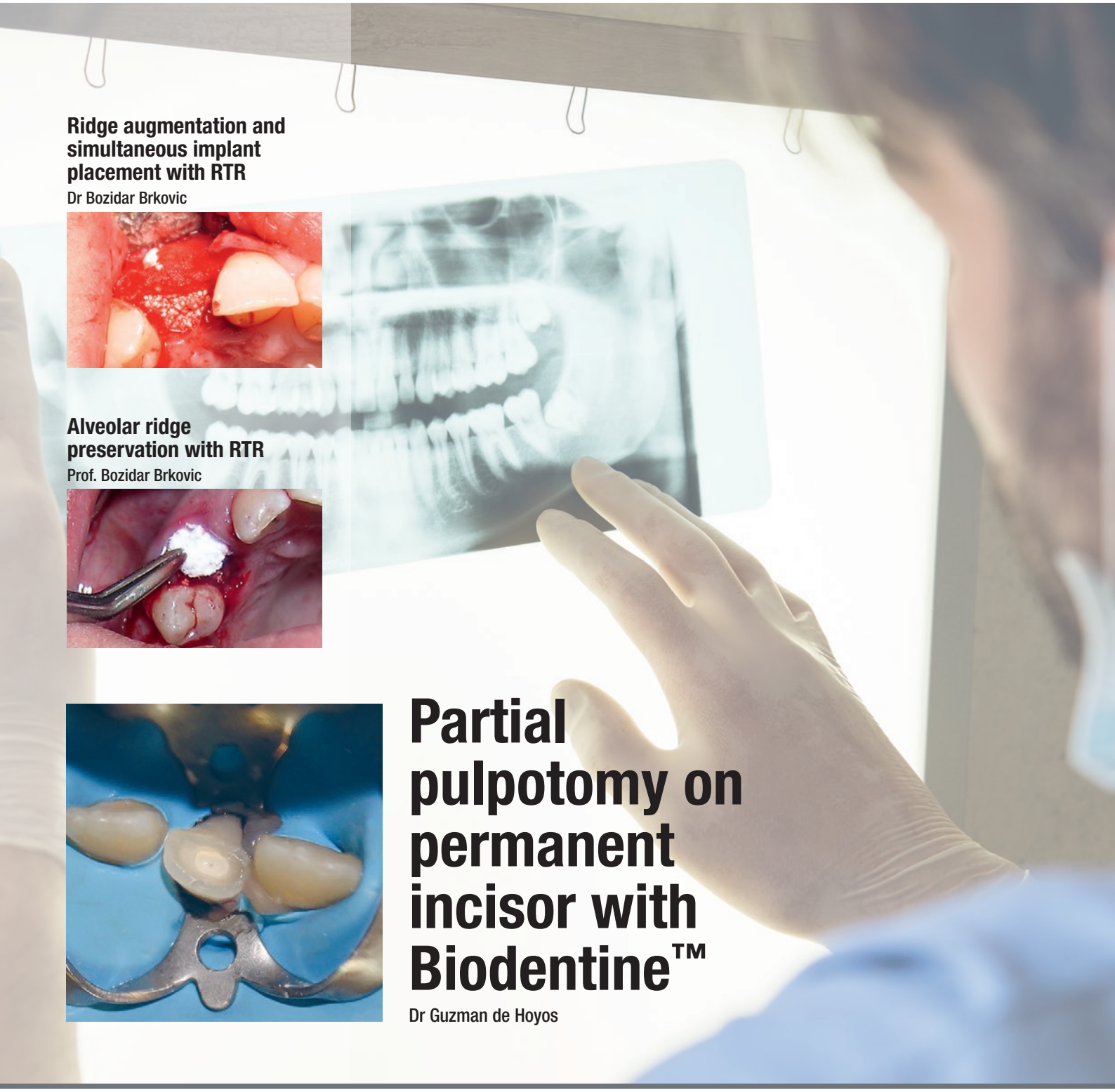
Septodont

# Case Studies Collection

No. 19 - January 2020



## Ridge augmentation and simultaneous implant placement with RTR

Dr Bozidar Brkovic



## Alveolar ridge preservation with RTR

Prof. Bozidar Brkovic





## Partial pulpotomy on permanent incisor with Biodentine™

Dr Guzman de Hoyos

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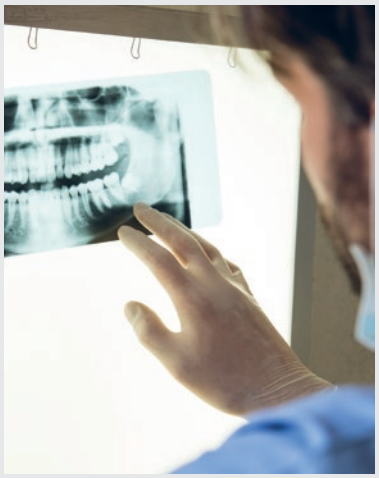
# Editorial



Since its foundation Septodont has developed, manufactured and distributed a wide range of high quality products for dental professionals.
Septodont recently innovated in the field of endodontics, dentine care, bone grafting and gingival preparation with the introduction of BioRoot™ RCS, Biodentine™, RTR and Racegel which are appreciated by clinicians around the globe.

Septodont created the *"Septodont Case Studies Collection"* - a series of case reports - in 2012 to share with you their experience and the benefits of using these innovations in daily practice. Over the past 6 years, authors from more than 15 countries have generously contributed to the success of our magazine that is now distributed on the 5 continents.
Each new issue of the Case Studies Collection is the opportunity to discover new clinical challenges and their treatment solutions.

This 19th issue features two RTR case and one Biodentine™ cases :

- RTR Bone grafting aims at preserving bone dimensions especially when tooth removal is discussed. It is fully resorbable & osteoconductive. Its remarkable properties promotes formation of patient's new bone & paves the way for future successful treatment plans.
- Biodentine™, the first biocompatible and bioactive dentin replacement material. Biodentine™ uniqueness not only lies in its innovative bioactive and "pulp-protective" chemistry, but also in its universal application, both in the crown and in the root.

# Content

# Partial pulpotomy on a lower permanent incisor with complicated fracture of the crown and open apex using Biodentine™. 13 months follow-up: a Case report

**Authors: Guzman de Hoyos A.I., Rodríguez Villarreal O., Reyes Martell Casale P., Yañez Pérez C., Molina Montoya D.E..**

## Abstract

Traumatology in pediatric dentistry is an important issue due to the early eruption of the permanent dentition and its consequences. Trauma in pediatric dentistry often involves permanent tooth and the treatment needs to be carefully selected by the clinician. There are several factors that are determinant in the prognosis and/or success of the treatment, such as duration of pulpal exposure, irreversible pulpitis signs, root development and the clinical scenario. [1,2]

The objective of this article is to present a trauma case in which a permanent lower incisor is involved. Based on the radiographic analysis and the anamnesis we decided to perform a partial pulpotomy. The biomaterial used was Biodentine™ and the tooth fragment was reattached. This is a 13-month partial pulpotomy follow-up.

# Introduction

Crown fractures and luxations occur more frequently of all dental injuries. An appropriate diagnosis and treatment plan are important for a good prognosis, the IADT (International association of dental traumatology) has developed a consensus about the procedures that enhance the prognosis and treatment success.[4]

Complicated fractures of the crowns should be managed as follows:

In young patients with immature, still developing teeth, is advantageous to preserve pulp vitality by pulp capping or partial pulpotomy. This treatment is also the choice in young patients with completely formed teeth.[4]

If too much time elapses between accident and treatment and the pulp becomes necrotic, root canal treatment is indicated to preserve the tooth.[4]

Partial pulpotomy is defined as the removal of a small portion of coronal pulp tissue after exposure, followed by application of a biomaterial directly onto the remaining pulp tissue prior to placement of a permanent restoration.[3]

Partial pulpotomy it is a Vital pulp therapy (VPT). Vital pulp therapy of immature teeth is performed to encourage physiological development and formation of the root end and apical closure; this procedure is also referred to as apexogenesis.[5,6]

The aim of apexogenesis is the preservation of vital healthy pulp tissue so that continued root development with apical closure occurs.[6,7]

Historically, calcium hydroxide used to be the material of choice for vital pulp therapy. Later, upon introduction of mineral trioxide aggregate (MTA), this bioactive material became the gold standard. Recently, some other calcium-silicate based cements from this aggregate were invented such as calcium-enriched mixture (CEM) cement and Biodentine™ that can be favorable vital pulp therapy agents.[6,7]

Biodentine™ (Septodont, Saint-Maur-des-Fossés, France) is a calcium-silicate based material and has several clinical applications. Biodentine™ is a bioactive inorganic calcium silicate-based cement that increases biomineralization and pulp cell proliferation.[8]

Biodentine™ presentation consists of powder and liquid components. The powder contains tricalcium silicate, dicalcium silicate, and calcium oxide; The liquid consists of calcium chloride and a carboxylate-based hydro-soluble polymer that serves as the water reducing agent.[8]

Biodentine™ is a very practical product, after 12 minutes a final restoration can be over it to promote the restoration seal and enhance the prognosis avoiding leaking and contamination of the pulp.

# Case report

Female patient 7 years and 6 months old arrives to the office with a dental trauma history. After the informed consent was signed we perform our clinical review protocol. On the clinical exploration we found a lower incisor with complicated fracture of the crown, according with the mother testimony it had been 2 hours since trauma occurrence ***(Fig 1, Fig 2)***.

Then we proceed to periapical X Ray and it was confirmed the communication of the pulp and the open apex. According the IADT

***Fig. 1:*** Initial situation.

***Fig. 2:*** Initial situation.

when a complicated fracture of the crown is presented and there is no signs of irreversible pulpitis we should maintain the pulpal vitality performing partial pulpotomy. In this case the partial pulpotomy has 2 objectives: to maintain the pulp vitality and promote the apex closure ***(Fig 3, Fig 4)***.

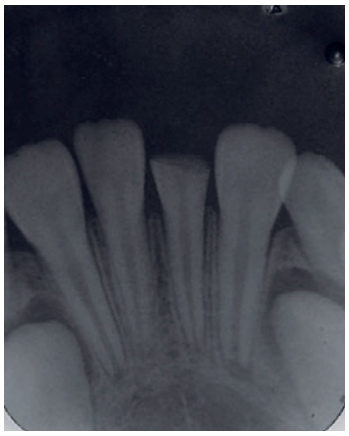


***Fig. 3:*** First radiograph.

***Fig. 4:*** Clinical situation, incisal view.

After the anesthesia (Scandonest, Septodont) was infiltrated we proceed to tooth isolation with rubber dam (Nictone, México), and Hu Friedy clamp. Partial pulpotomy was performed with diamond ball bur, high speed with water irrigation handpiece. The bleeding was controlled with sterile cotton pellets. Disinfection was made with sodium hypochlorite for 1 minute.

A Biodentine™ capsule was used as per the manufacturer instructions: capsule was placed on the white capsule holder, the liquid container was detached and then 5 drops were poured into the capsule, capsule was mixed for 30 seconds, Biodentine™ was placed direct on the amputated pulp and was gently packed with a sterile pellet ***(Fig 5-8)***.

After Biodentine™ was placed, adhesive procedures were done, the tooth fragment was beveled with a high speed diamond bur to

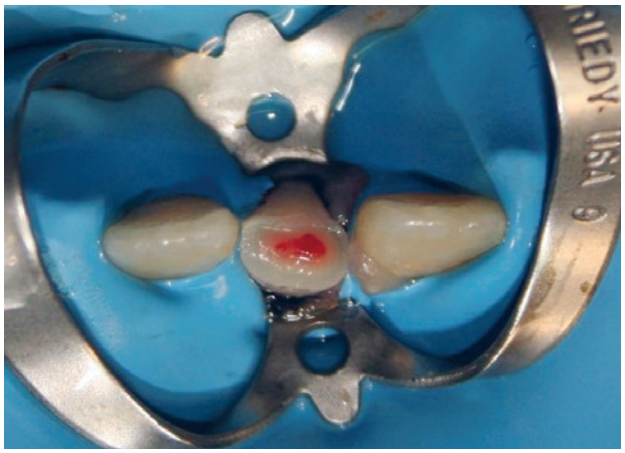


***Fig. 5:*** Isolation achieved.

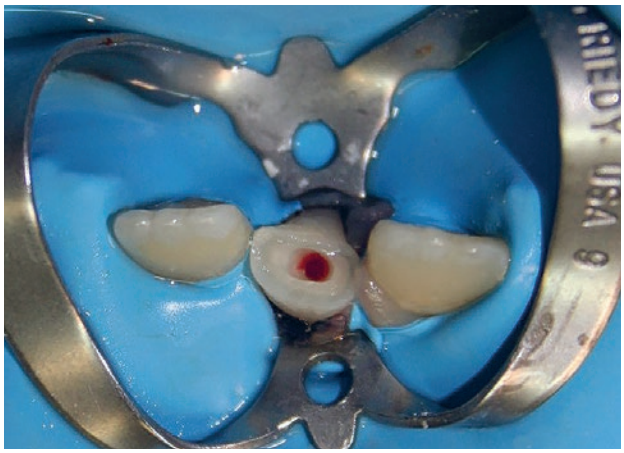


***Fig. 6:*** Partial pulpotomy.


***Fig. 7:*** Biodentine™ capsule and liquid.

***Fig. 8:*** Biodentine™ setting after 12 minutes.

enhance adhesion, selective enamel etch was performed with phosphoric acid (Ultra Etch) for 15 seconds, after rinsing and drying, a Premio Bond (GCAmerica) was placed and after 20 seconds was light cured, reattachment was done with fluid resin (Brilliant Flow, Coltene) and then finishing and polishing were done ***(Fig 9-12)***. The first radiograph was done immediately postoperatively, the second radiograph was done 30 days after treatment. radiograph and follow-up pictures were done after 13 months. ***(Fig 13-16)***.

***Fig. 9:*** Tooth was beveled.

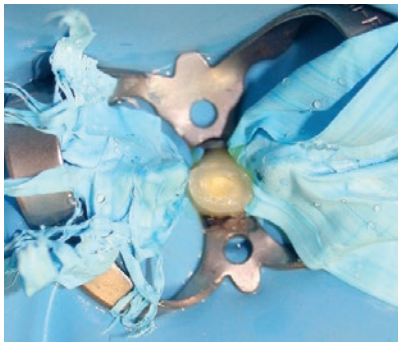


***Fig. 10:*** GC Premio bond after enamel selective etch.

***Fig. 11:*** Picture after light curing: frontal view.

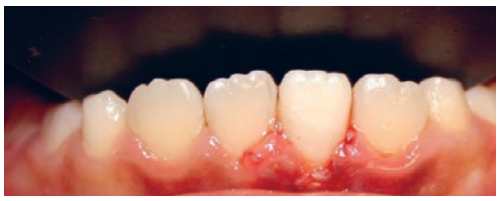


***Fig. 12:*** After finish and polish.

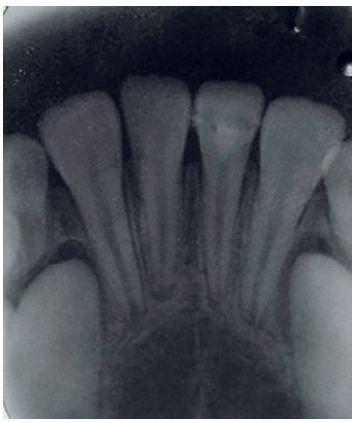


***Fig. 13:*** Inmediatly after treatment.

***Fig. 14:*** After 30 days.

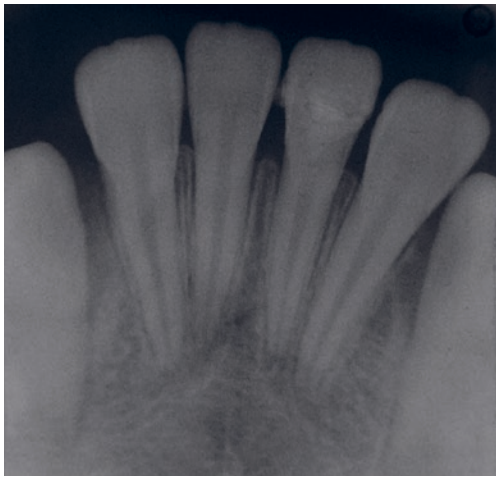


***Fig. 15:*** 13 Months radiographic control.

***Fig. 16:*** 13 Months clinical control.

# Discussion

As literature suggest the treatment for complicated fractures of the crown depends on several factors as root development, pulpal exposure duration, irreversible pulpitis among others. In cases with open apex, healthy pulp and short exposure time, partial pulpotomy could be done with a biomaterial as Biodentine™ that promotes the pulpal health, apex closure and allows us to perform a definitive restoration on top of it.

# Conclusion

Biodentine™ is a biomaterial with several indications, in cases of trauma specially when pulp is involved can be used in order to preserve the pulp vitality and allow the correct development of the tooth. In this case, Biodentine™ was used in a partial pulpotomy on a lower central incisor and after 13 months follow up it has promoted the apex closure and kept the pulp vitality.

The use of Biodentine™ in cases like this can be done with excellent clinical and radiographic results.

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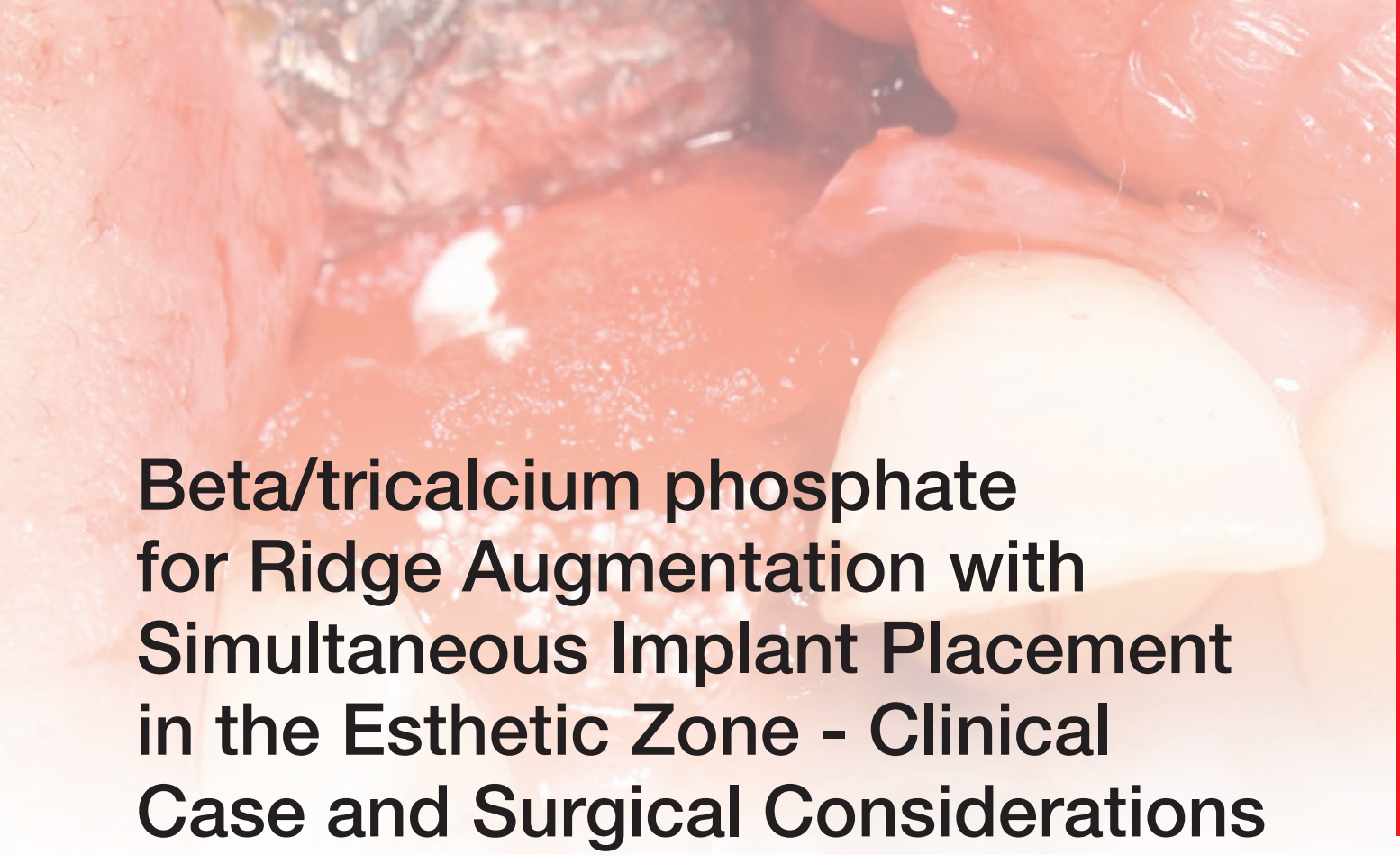

# Beta/tricalcium phosphate for Ridge Augmentation with Simultaneous Implant Placement in the Esthetic Zone - Clinical Case and Surgical Considerations

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## Introduction

Long-term aesthetics, associated with functionality, are integral part of successful implant treatment in well-defined esthetic zone. However, implant placement in the esthetic zone is a complex procedure that requires strict preoperative planning and precise surgical procedure based on prosthodontic-driven concept.

Following tooth extraction, implant can be placed in different time of bone and soft tissue healing, but predictable results should be weighed against the possible risk factors. Therefore, several timing of implant placements following tooth extractions are indicated depending of diagnostic factors of significance to the pre-operative examination of the aesthetic risk to the treatment outcomes (Chen, Buser 2008).
Mostly, because of dimensional bone changes after tooth extraction, unpredictable alveolar bone resorption may occur. The bone resorption affects buccal bone wall predominantly since vulnerable type of the bundle bone is integral part of buccal socket wall. However, dimensional changes affect a vertical dimension as well, resulted in difficulty of treatment and decrease of surgical success (Araujo et al. 2005, Chen et al. 2004). Therefore, different augmentation procedures are attempted to increase successful implant treatment in those patients. Having in mind all disadvantages of autogenous bone transplants, synthetic biomaterials can be useful to obtained sufficient bone volume prior to implant placement.
The aim of this report was to show indication when synthetic beta-tricalcium phosphate was used for localized alveolar ridge augmentation simultaneous with implant placement in the maxillary esthetic zone.

# Case report

A 25-year-old healthy male non-smoker was referred to the Clinic of Oral Surgery, University of Belgrade, for implant placement in the position #12, 14 weeks after tooth extraction. After the consolidation, the date obtained were compiled for the esthetic risk-assessment table which showed a low esthetic risk having in mind medium patient's esthetic expectation, medium lip line position, thick and medium scalloped gingival biotype with intact and well defined keratinized gingiva (Figure 1). Positive effect was also confirmed with the rectangular crown shape associated with less than 5 mm to contact point at the adjacent teeth. The width of edentulous span enabled the restoration of one tooth ***(Fig. 1)***. No infection of residual alveolar ridge was diagnosed. Close inspection of the treated site determined horizontal deficiency which confirmed the need for a bone-augmentation procedure to address the buccal bone morphology ***(Fig. 2)***.

***Fig. 1:*** Clinical observation before implant placement and bone augmentation

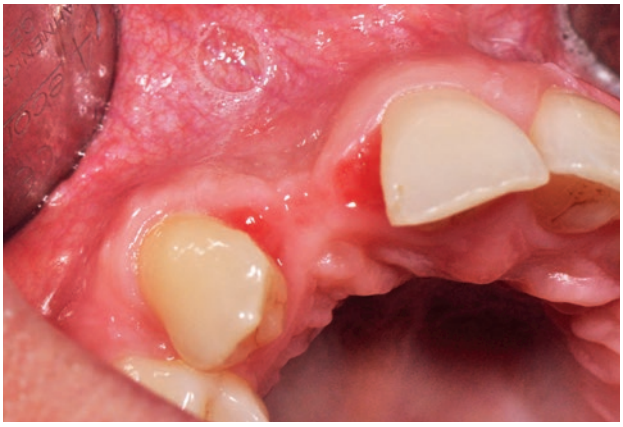

***Fig. 2:*** Clinical observation of horizontal bone resorption

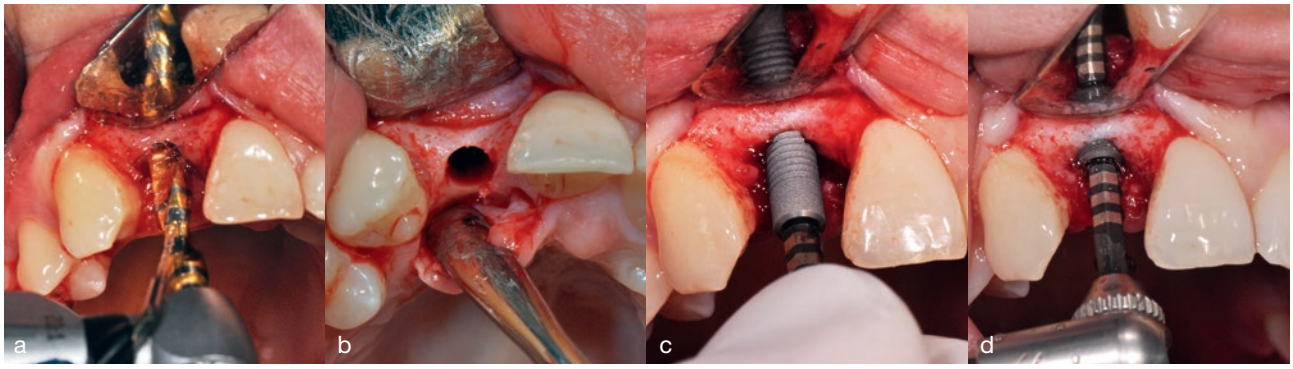


***Fig. 3a, b, c, d:*** Surgical procedure of AstraTech TX implant placement in the maxillary esthetic zone

Under local anesthesia, a full-thickness flap was created with a crestal incision. The flap was extended through the sulcus of the adjacent teeth and elevated with a fine tissue elevator to allow low-trauma soft-tissue handling. Following flap elevation, the surgical site was carefully analyzed for sufficient bone and soft-tissue volume prerequisite for surgical treatment related with insertion of AstraTech TX implant ***(Fig. 3 a, b, c)***. The horizontal and vertical dimensions of alveolar ridge allow a correct three-dimensional position of an implant in the comfort zone ***(Fig. 4)*** with simultaneous bone augmentation since

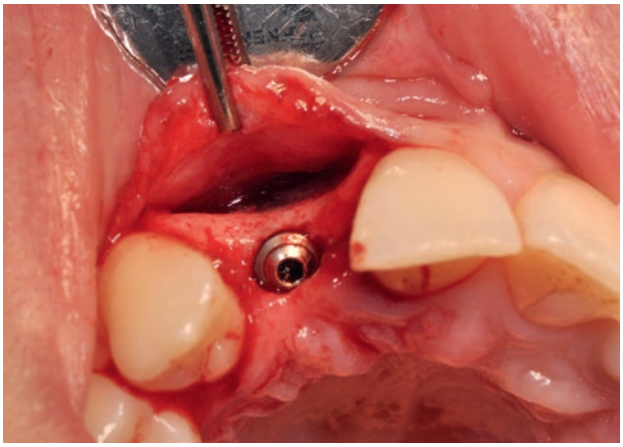

***Fig. 4:*** Correct three-dimensional implant position

thin buccal bone wall ensure visualization of implants threads (***Fig. 5***). Bone augmentation was performed using beta-tricalcium phosphate (ßTCP) (RTR Syringe, Septodont, France). The procedure, which included a slight overbuild of the buccal contour of the alveolar bone, was intended to provide the required support and long-term stability for the overlaying soft tissue. In connection with a hemocollagen sponge (Septodont, France) was applied in two layers to create the condition for a ßTCP protection and buccal-gingival support during tissue regeneration procedure ***(Fig. 6 a, b, c)***.

After implant placement, initial stability of 81 ISQ was obtained ***(Fig. 7)***. The implant site was healed uneventfully. No signs or symptoms of complications were detected ***(Fig. 8 a, b)***. Since guided tissue regeneration was done, temporary implant-supported restoration was planned after 2 months of healing ***(Fig. 9)***.

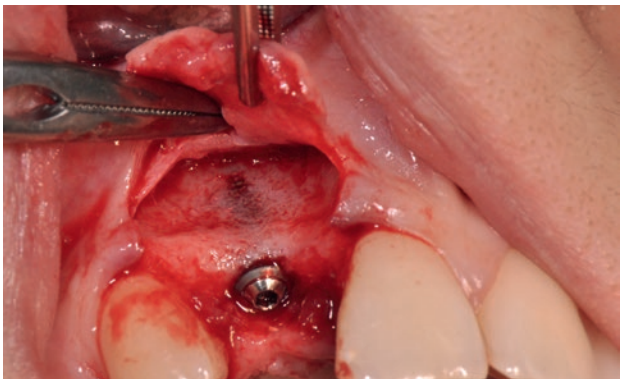

***Fig. 5:*** Indication for buccal bone augmentation procedure

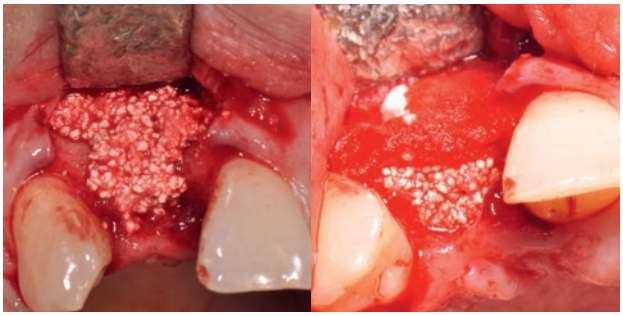

***Fig. 6a, b:*** Usage of ßTCP for bone augmentation with implant placement - lateral view

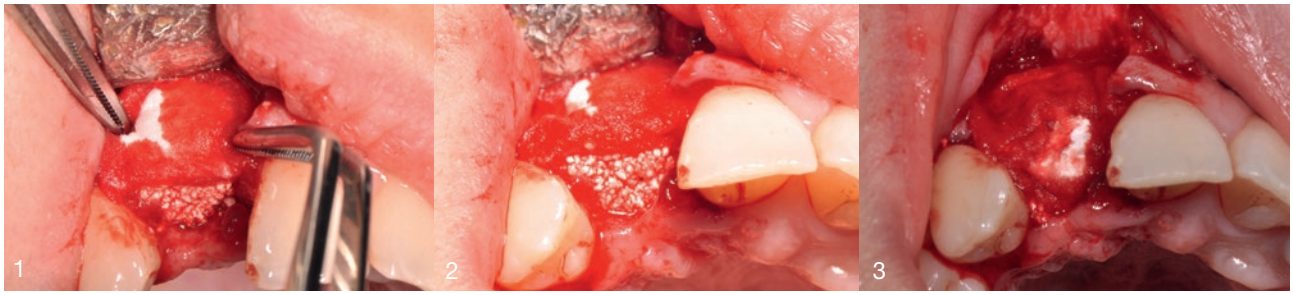


***Fig. 6c (1, 2, 3):*** Position of hemocollagen covering particles of ßTCP


***Fig. 7:*** Initial stability of inserted implant

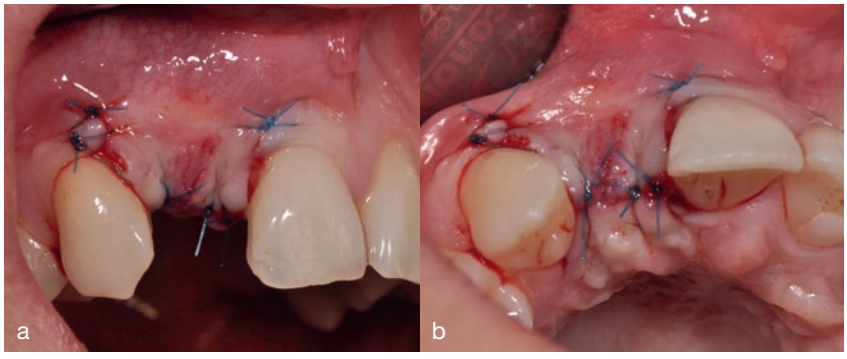


***Fig. 8a, b:*** Postoperative view

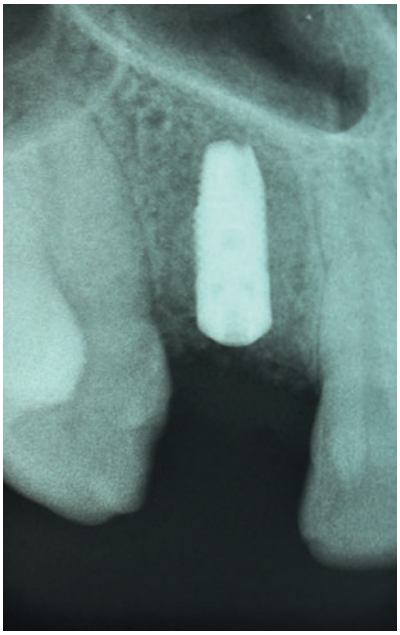

***Fig. 9:*** Radiography 2 months after implant placement with simultaneous ßTCP bone augmentation

# Discussion

There are several reasons to consider placement of dental implant early after partial bone healing, 14 weeks after tooth extraction (Type 3 timing of implant placement). Partial bone healing usually allows implant stability to be more readily attained with additional soft tissue volume, which may enhance soft tissue aesthetic outcomes. The quality and quantity of newly formed bone is quiet enough to obtained initial stability, as well as later osteointegration process, for implants placed in highly vascularized region of bone with a significant number of signaling molecules to accelerate bone healing. The healing period prior to implant placement allows resolution of any pathology associated with the extracted tooth while, additional soft tissue volume ensures easier attainment of tension-free closure in two-stage surgical approach. Conversely, two surgical procedures and extended treatment time are required. Regarding the healing period of socket walls, horizontal bone resorption is evident what can limit the volume of bone for implant placement (Markovic, Misic 2016).

Although a flattening of facial bone contours facilitates grafting of the facial surface of the bone, in majority of cases selected for Type 3 timing of implant placement, if happened, peri-implant defects are often present as two-or three-walled defects, which are favourable for simultaneous bone augmentation procedures as it has been presented. In those cases, synthetic bone substitutes can be used to improve bone healing.

Placement of biomaterial over the facial surface of buccal bone provides a scaffold for the in-growth of cellular and vascular components to form new bone of acceptable quality and quantity. The main characteristic of ßTCP particles is osteoconductive property. When mixed with a blood clot, osteogenic cells from surrounding bony walls, migrate inside and over the ßTCP particles. The cellular level of activity is also stimulated indirectly by the adhesive glycoprotein and fibronectin which are the first components accumulated at the ßTCP particles, supporting the process of osteoblastic differentiation and proliferation (Zerbo et al. 2001, 2005).

Significant resorption of ßTCP particles is expected between 3 to 6 months, while delay-time period of resorption was seen after 9 months when ßTCP in combination with Type I collagen was used for alveolar ridge preservation procedure (Brkovic et al. 2008, 2012). During observation time of bone healing, ßTCP become well incorporated into a new bone formation creating a dense cancellous bone. This biological status may significantly improve ability to withstanding loading forces transmitted by implants especially at the buccal vulnerable bone when it is used simultaneously with implant placement. Another biological characteristic of ßTCP is biodegradation occurs by both osteoclastic activity and chemical dissolution by tissue fluids (Fujita et al. 2003). Since ßTCP is a highly porous material, it is dissolved in particles well incorporated into newly formed bone and lacunar osteocytes system, continuing with a process of bone modeling and re-modeling.

Successful surgical result, with no significant differences, was presented in a one-stage procedure for horizontal bone augmentation when anorganic bovine bone and pure ßTCP both with bio-membrane were compared (Merli et al 2015). Also, in different surgical indication, ßTCP may be indicated. Kilic et al. (2017), investigated the influence of P-PRP or PRF on ßTCP-induced bone healing, showed findings of beneficial sinus-floor augmentation with ßTCP alone. Additionally, ßTCP presented satisfactory result for maxillary sinus lifting procedure regarding the maintenance of graft volume during the healing before the implant placement (Gorla et al. 2015), or 2.5 years after surgery (Okada et al. 2016), as assessed by means of CBCT.

This case report suggests that the use of ßTCP simultaneous with implant placement may result in the stable surgical outcome during the early bone healing phase.

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**Dr Božidar Brkovic** (DMD, MSc, PhD) is Professor of Oral Surgery, Implant Dentistry and Dental Anesthesia employed at the School of Dental Medicine, University of Belgrade, Serbia since 1998. He completed his specialization program of oral surgery at the same university in 2004. From 2006 to 2007 he attended a Postdoctoral Fellow Program at Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, University of Toronto, Canada, as well as a Scholar Program at Division of Oral and Maxillofacial Pathology, School of Dentistry, University of Minnesota, USA, focusing on implant dentistry and regenerative treatments of bone and soft tissue. In that field, Prof Brkovic was completed different research programs of molecular, cellular and tissue level of oral tissue regeneration in healthy and diabetic patients and animal models collaborated with University of Liege, Belgium, University of Tampere, Finland, Companies Dentsply Sirona, Straumann, Nobel Biocare. Special interest was obtained with Septodont Company, France, which included 2 Grants for bone regeneration treatments and local anesthesia in experimental and clinical cases. He published 32 original articles, several chapters, books and presented over 90 lectures.
He is a mentor of 10 PhD thesis involved in several domestic and international scientific projects and an opinion leader for clinical courses and education for Septodont and AstraTech Implant System. Prof Brkovic has been an ITI Fellow since 2008. He is currently professor of integrated and postgraduate programs of oral surgery, implantology and dental anesthesia at the University of Belgrade.

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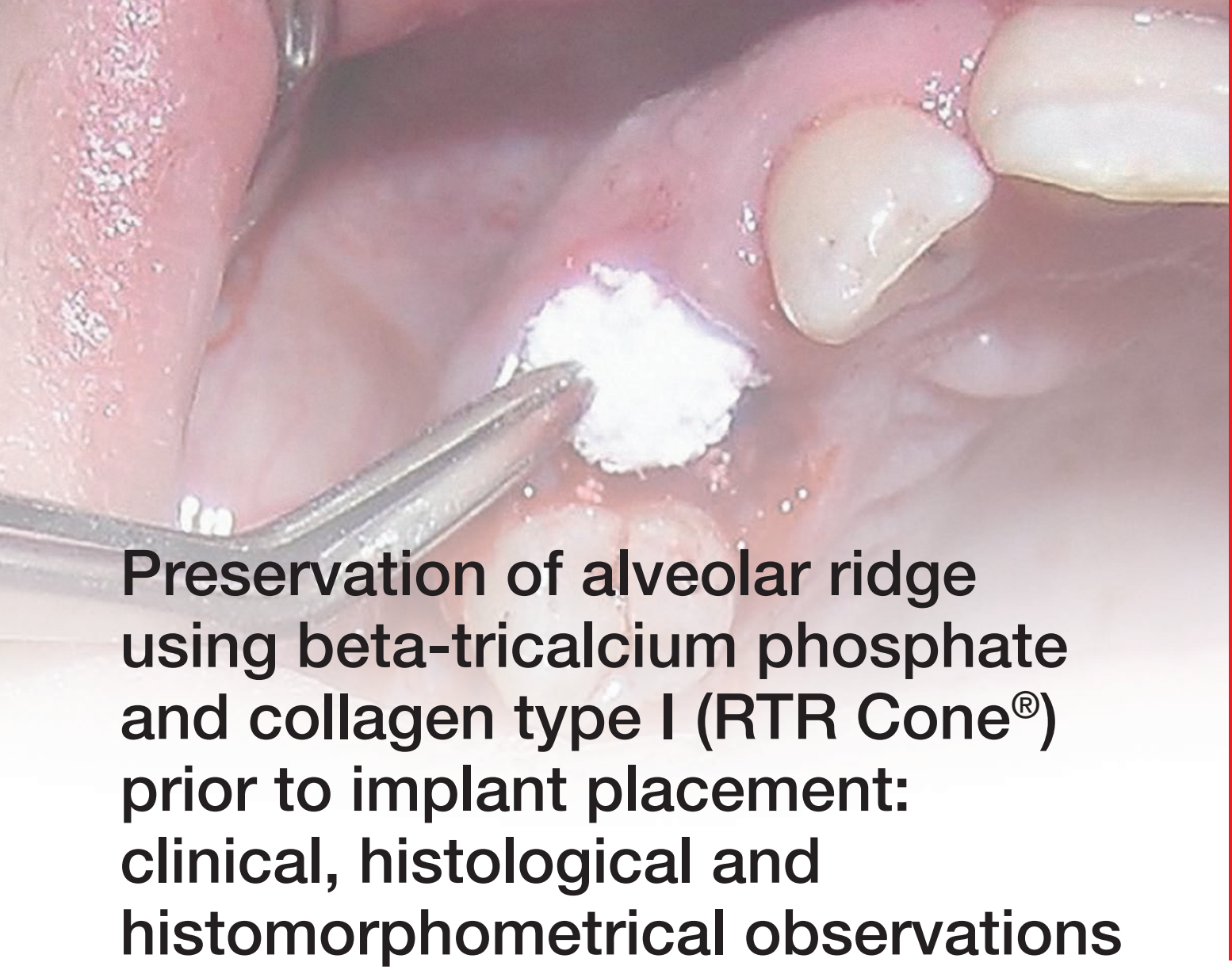

# Preservation of alveolar ridge using beta-tricalcium phosphate and collagen type I (RTR Cone®) prior to implant placement: clinical, histological and histomorphometrical observations

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## Introduction

Following tooth extraction, blood clot develops inside the socket walls and finally leads to new bone formation. However, this healing process never allows complete restitution of initial volume of alveolar ridge due to well-known physiological bone resorption. These resorption process varies amongst individual patients and tooth position, and may be additionally affected by presence of local infection sites, periodontal disease, alveolar bone fenestrations as well as thickness of the alveolar socket buccal bone walls (Garg et al. 2001).

Healing process of bone tissue after tooth extraction results in dimensional changes of residual alveolar ridge in both dimensions, horizontal dimension with modification of alveolar bone width, and vertical dimension which affects the height of alveolar bone. These tissue changes have been reported as leading 40-60% decrease in the both dimensions (Farmer and Darby 2014), with significant reduction in the first 3 months after tooth extraction resulting in bone and soft tissue level that is lower than that of adjacent teeth, what was predominantly seen

after multiple adjacent extractions (MacBeth et al. 2016, Chen et al 2004). Regarding the soft tissue remodeling after tooth extraction, the volumetric reduction and subsequent soft tissue contour change have been occurred, narrowing of the keratinized mucosa and attached gingiva (Schneider et al. 2014, Thoma et al. 2009).
To reduce the loss of alveolar bone and soft tissue to an acceptable level, the preservation of alveolar ridge has been proposed. These may include minimal traumatic extraction, followed by immediate grafting of the extraction sites using biomaterials, without the use of barrier membranes, if integrity of the socket 4-walls is presented (Brkovic et al. 2008). In addition to the function of biomaterials that replace the missing portion of alveolar bone, space provision and blood clot stabilization inside the biomaterials, offer osteoconductive and, later, osteoiductive properties of biomaterials (Aybar et al. 2004, Zerbo et al. 2001).
Beta-tricalcium phosphate (ßTCP) is alloplastic, biocompatible, synthetic material produced by Septodont, France, indicated in different clinical cases in oral surgery, periodontal surgery and implantology, used in 2 forms, particulate (R.T.R. Syringe® - plain ßTCP) or conical form (R.T.R. Cone® - ßTCP + Type I collagen). It has been documented the use of ßTCP for the preservation of alveolar ridge immediately after tooth extraction, prior to implant placement, in the combined form of ßTCP and Type I collagen (Brkovic et al. 2012).

# Case report with surgical considerations

Healthy patient who required tooth extraction was evaluated for post-extraction socket preservation prior to dental implant placement in the frontal part of upper jaw.
After minimal invasive extraction of #13 was performed under local anesthesia, clinical examination was done to detect a socket 4-walls integrity, to clean debris of post-extraction sites and to remove chronical granulation tissue peri-radicular ***(Fig. 1)***. A single R.T.R. Cone® containing beta-tricalcium phosphate with type I collagen (ßTCP/Clg) (Septodont, Saint-Maur-des-Fosses, France) was placed into the internal socket space ***(Fig. 2)***. To obtained as a larger area of bone/material contact, ßTCP/Clg cone was trimmed to the more conical form to completely occupy the space from the marginal edge of alveolus to the apex of the socket. Regarding that, trimmed particles of ßTCP/Clg were firstly inserted into the narrow apical part of socket, while the rest of socket space, middle and cervical part, was filled with trimmed solid conical form. After cone placement, the alloplastic material and socket opening was left to heal spontaneously without the use of barrier membrane or a mucoperiosteal flap ***(Fig. 3)***. In case of multiple adjacent teeth extractions, interrupted sutures can be positioned at the level of mesial and distal papillae.
A 7-day course of amoxicillin 500 mg per oral and pain control medication as required were prescribed and detailed

***Fig. 1:*** Extraction socket with 4-walls prepared for filling with betaTCP/Clg (taken from Brkovic et al. Clin Oral Invest 2012,16:581-590).

***Fig. 2:*** betaTCP type 1 collagen cone placed into socket (taken from Brkovic et al. Clin Oral Invest 2012,16:581-590).

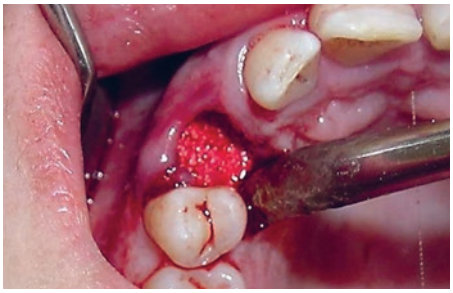

***Fig. 3:*** betaTCP type 1 collagen cone trimmed to fit snugly into socket with blood clot inside the material (taken from Brkovic et al. Clin Oral Invest 2012,16:581-590).

postoperative instructions were given to patient. The control of soft tissue healing was done at days 3 and 7, and then at 4 and 9 months after the preservation for clinical control of bone and soft tissue healing associated with the radiographic evidence *(Fig. 4, 5)*.

*Fig. 4:* Healing of mucosa around non-membrane betaTCP type 1 collagen filled socket, 1 week following placement (taken from Brkovic et al. Clin Oral Invest 2012,16:581-590).

*Fig. 5:* Alveolar ridge exposed at biopsy and implant placement 9 months following socket preservation with betaTCP type 1 collagen without a barrier membrane (taken from Brkovic et al. Clin Oral Invest 2012,16:581-590).

# Results

The presented results of clinical and histological outcomes after 9 months of healing were published in Clin Oral Invest 2012, 16:581- 590, while results of 4 months of healing were presented at EAO 2016.

## Clinical outcomes

Clinical results were evaluated after 4 and 9 months of healing. There was no significant difference between observed times in the vertical and horizontal dimensional changes *(Table 1)*, while characteristics of grafted area at the time of implant placement were different *(Table 2)*. Four months healing period was determined with less drilling and bone-like resistance, mostly flexible with significant evident of particles inside the treated sites. All treated sites healed uneventfully with completed gingiva closure of socket opening in 2 weeks, in both observation times.

**Table 1: Changes of alveolar ridge dimension (mm)**

| Characteristics | 9 months of healing | 4 months of healing | P |
|---|---|---|---|
| Horizontal dimension | 6.59 ± 2.44 | 5.13 ± 2.89 | NS |
| Vertical dimension / buccal aspect | 3.60 ± 1.51 | 3.10 ± 2.18 | NS |

**Table 2: Time for complete epithelization of socket opening and clinical characteristics of grafted area at the time of implant placement (mean ± SD)**

| Characteristics | 9 months of healing | 4 months of healing | P |
|---|---|---|---|
| Epithelial closure of socket opening (day) | 19.1 ± 4.7 | 20.3± 6.7 | NS |
| Visibility of particles (yes/no) | 4/7 | 9/1 | p=0.03 |
| Continuity with native bone(yes/no) | 11/0 | 5/5 | NS |
| Fibrous adhesions (yes/no) | 2/9 | 4/7 | NS |
| Purulent discharge(yes/no) | 0/11 | 0/11 | NS |
| Drilling resistance (bone quality) | | | |
| Decreased resistance | 4 | 7 | NS |
| Bone-like resistance | 7 | 3 | NS |
| Probing resistance | | | |
| Hard | 6 | 3 | NS |
| Flexible | 4 | 5 | NS |
| Soft | 1 | 2 | NS |
| Reduction of attached gingiva (yes/no) | 0/11 | 0/10 | NS |
| Reduction of attached gingiva (yes/no) | 0/11 | 0/10 | NS |

## Histology

Both healing periods, 4 and 9 months, have shown mineralized trabecular bone type characterized by a presence of woven in comparison with lamellar bone in 4 months of healing, while immature lamellar bone was evident in 9 months period predominantly in aplical and peripheral parts of bone samples ***(Fig. 6, 7)***. Trabecular bone was lined with active osteoblast and osteoblast-liked cells with all characteristics of new bone formation (irregularity in shape and position of lacunas, osteocysts as a sign of vitality, reversal lines as a sign of different dynamic in bone formation and maturity) ***(Fig. 8)***. Particulate non-resorbable granules of ßTCP were very well incorporated inside the new bone formation without inflammatory cell infiltration and fibrous tissue reaction ***(Fig. 9)***.

## Histomorphometric outcomes

Histomorphometric analysis has shown significant difference in new bone formation and marrow bone between 4 and 9 months of healing with more bone occupied sites that healed longer. More, but not significant, reduction of residual graft was recorded after 9 months of healing in comparison with 4 months of healing. Fibrous tissue was mostly evident in earlier phase of healing of 4 months than after 9 months of healing (Table 3).

**Table 3: Histomorphometric results (%)**

| Characteristics | 9 months of healing | 4 months of healing | P |
|---|---|---|---|
| New bone | 42.4 ± 14.6 | 30.8 ± 7.2 | .05 |
| Marrow | 42.7 ± 10.9 | 24.3 ± 11.4 | .05 |
| Residual graft | 9.7 ± 7.3 | 18.5 ± 9.0 | NS |
| Fibrous tissue | 4.4 ± 3.6 | 26.4 ± 4.8 | .05 |

# Discussion

Results of the study demonstrate that betaTCP/Clg provides an effective bone regenerative network which can allow in-growth of active cellular and vascular components inside the material. This characteristic of osseoconductive material will enable a formation of new mineralized bone and bone marrow in a human extraction socket after using betaTCP/Clg for preservation of alveolar ridge. Histological evidence which was presented with newly formed bone, lined with osteoblast and osteoblast-liked cells, demonstrated that active bone formation was still in process 4 and 9 months after preservation. Furthermore, the evidence that active osteoblasts produce osteoid, as first evidence of bone tissue, taking places not only around new bone but also inside the material porosity system, resulted finally with the appearance of new centers of ossification. The biological contribution of calcium ions and collagen type I improves induction potential of grafted sites to surrounded vital bone for cells migration and growth factor penetration supporting osteoblastic differentiation and proliferation resulted in acceleration of the healing process in bone defects (Pioletti DP et al. 2000, Barrere et al. 2006). Next, the well incorporated particles of betaTCP inside the new bone confirm biocompatibility and activity of ossification (Thompson et al. 2006).

The alveolar crestal bone level did not change significantly over the time of bone healing in 4 and 9 months in both directions, vertical and horizontal. On the other hand, the expected resorption of the alveolar bone during the physiological healing of extraction sockets is usually seen with the significant changes in the first 3 months after the extraction (Chen et al 2004). That way, preservation of alveolar ridge after tooth extraction and prior to implant placement

might be clinically relevant option having in mind stability of post-extraction sites and prevention of its resorption. Another important thing is that a mucoperiosteal flap and barrier membrane for guided bone regeneration have not played any crucial rule in case with all four-wall socket preservation what was also documented by Herberer et al using BioOss + Collagen in the same model of human socket preservation. There are several possible mechanisms to explain the blockade of fibrous tissue in-growth into the porous material structure of the ß-TCP granules. Metabolites and a local decrease in pH during the material dissolution can inhibit the fibroblastic proliferation, while afterward that process will be intensive by a strong connection of material and bone through the ion's reaction (Pioletti et al. 2000, Zerbo et al 2005).

Preservation of alveolar ridge have been recorded as changing the structural and histological characteristics of the bone and gingival tissue with the goal for promoting the establishment of an adequate functional, biological and aesthetic foundation before implant supported prosthodontics. If alveolar bone walls are still preserved, they can provide blood supply as well as mechanical support for the placement of a bone-filling material in the resorption site and maintain the initial volume of bone (Cortellini and Tonetti 2015). Additionally, clinical results of soft tissue stability indirectly demonstrated positive influence of preservation method on the design of the final implant supported crowns improving the emergence profile of the restoration with increase in the gingival papilla height and expression of the fixed keratinized tissue dimensions (Belser et al. 2004).

Regarding the results of this clinical study, it can be concluded that the combination of betaTCP/Clg can prevent the reduction of original dimension of the alveolar bone when used for the preservation of four-wall extraction socket without the barrier membrane and surgical flap used. The active bone formation ensured the quality of regeneration important for successful implant osseointegration suggesting both 4 and 9 months of healing as a relevant from the point of safe and successful implant placement.


**Author:**

**Dr Božidar Brkovic** (DMD, MSc, PhD) is Professor of Oral Surgery, Implant Dentistry and Dental Anesthesia employed at the School of Dental Medicine, University of Belgrade, Serbia since 1998. He completed his specialization program of oral surgery at the same university in 2004. From 2006 to 2007 he attended a Postdoctoral Fellow Program at Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, University of Toronto, Canada, as well as a Scholar Program at Division of Oral and Maxillofacial Pathology, School of Dentistry, University of Minnesota, USA, focusing on implant dentistry and regenerative treatments of bone and soft tissue. In that field, Prof Brkovic was completed different research programs of molecular, cellular and tissue level of oral tissue regeneration in healthy and diabetic patients and animal models collaborated with University of Liege, Belgium, University of Tampere, Finland, Companies Dentsply Sirona, Straumann, Nobel Biocare. Special interest was obtained with Septodont Company, France, which included 2 Grants for bone regeneration treatments and local anesthesia in experimental and clinical cases. He published 32 original articles, several chapters, books and presented over 90 lectures.

He is a mentor of 10 PhD thesis involved in several domestic and international scientific projects and an opinion leader for clinical courses and education for Septodont and AstraTech Implant System. Prof Brkovic has been an ITI Fellow since 2008. He is currently professor of integrated and postgraduate programs of oral surgery, implantology and dental anesthesia at the University of Belgrade.

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