Evaluation of treatment of intra-bony defects with a mixture of β-tricalcium phosphate - hydroxyapatite granules and oily calcium hydroxide suspension

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ABSTRACT

Background: An oily calcium hydroxide formulation proved over the last years to be highly efficient in promoting bone regeneration in closed defects as periapical lesions, cysts, or post-extraction defects. The aim of the present study is the assessment of the outcome of treatment of deep intrabony periodontal defects with an Open Flap Debridement) (OFD) + combination of {(30% Hydroxyapatite HAp + 70% β-Tricalcium Phosphate granules mixed with an Oily Calcium Hydroxide Suspension (OCHS)} and compare the results with {(OFD) alone)}. The combination of OCHS& TCP was used in humans with a sort of positive results, and more conduction of studies was recommended.
Material and method: The sample of this study composed of sixteen patients; each had at least two intrabony defect teeth. For each patient, one tooth was treated by OFD only (control group 16 teeth) and the other teeth (study group 16 teeth) were treated with OFD + a mixture of (OSTEON II- Korea) granules comprise of (30% Hydroxyapatite HAp + 70% β-Tricalcium Phosphate) and OCHS (Osteoinductal®, Osteoinductal GmbH., Muenchen, Germany). The clinical parameters that were measured and recorded included (Plaque index PLI, Gingival index (GI), Gingival recession(GR) , Bleeding on probing (BOP), probing pocket depth (PPD), clinical attachment level (CAL) and radiographical width & depth of the bony defect. These parameters were recorded before treatment (base line) & six months after the treatment.
Results: The results after treatment revealed a highly significant reduction in all of the parameters except the PLI in both study & control groups compared to baseline ($p < 0.001$). The clinical results were indicated that the study group showed significant reductions of PPD and CAL mean values more than improvements obtained by the control group with significant difference ($p < 0.05$).
Conclusions: An excellent postoperative improvement in clinical parameters was noticed in the study group more than control group and the differences were significant. Thus the present study has revealed that the treatment modality of OFD + a combination of granules comprise of (30% Hydroxyapatite HAp + 70% β-Tricalcium Phosphate) mixed with oily Calcium Hydroxide suspension is successful, predictable and more beneficial than (open flap debridement) (OFD) alone in the treatment of deep intrabony periodontal defects.
Key words: Intrabony defects, β-TCP, Hydroxyapatite, OCHS. (J Bagh Coll Dentistry 2013; 25(3):103-109).

INTRODUCTION

Regeneration of the lost periodontium has long been a goal of periodontal therapy. Periodontal disease associated with vertical bony defect formation provides therapists with the opportunity to regenerate the lost periodontium, which can effectively re-establish health and improve support for the dentition. Periodontal regeneration is defined as the restoration of alveolar bone, cementum, and a functionally oriented periodontal ligament on a previously diseased root surface [(1)]. While the definition of periodontal regeneration is based upon histology, surrogate measures such as radiographic bone fill, probing depth reduction, and gain in clinical attachment level are used most often when clinically evaluating treated sites [(2)].

The aim of periodontal regeneration is complete reconstruction of supporting structures lost as a result of periodontal disease. In recent years, many researchers have reported different treatment modalities to promote the regeneration of lost periodontal structures. Described methods include: diverse flap preparation methods [(3-5)], biomodification of root surfaces with enamel matrix derivative (EMD) proteins [(6,7)], guided tissue regeneration (GTR) [(8-10)] and use of growth factors [(11)].

One of the most important factors affecting the results of periodontal regeneration is the keeping of the adequate space for the healing process. The significant problem is a collapse of mucoperiosteal flap into the bone defect [(12)] especially when using low consistency & soft with high fluidity materials like (EMD) & (OCHS). Therefore, there is need for a scaffold, supporting the flap and stabilizing the blood clot [(13)].

Results from controlled clinical studies have shown that treatment of intrabony defects with open flap debridement (OFD) alone may lead to corresponding clinical results as after the adjunctive use of different biomaterials like β-Tricalcium Phosphate and calcium phosphate bone cement [(14,15)]. On the other hand, there have been reports showing, that, after bone defect filling with biomaterial, the clinical results may be superior to that achieved with the OFD procedure alone [(16)].

Results of clinical studies have reported the influence of an oily Calcium Hydroxide suspension (OCHS) on bone regeneration in

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closed bony defects subsequent to periapical surgeries, in bone cysts and post-extraction alveolae [17]. Its osteostimulative effect is due to many factors, as the deposit action of the calcium hydroxide, which sustains the bone metabolism in a constant, mild alkali environment, the stimulation of the angiogenetic bone growth with concentration of the growth factors next to the defect wall, and the reduction of the inflammation in the operated site, which enhances the wound healing [18]. Histological and radiological analysis, both in animals and humans seem to indicate a predictable regeneration of closed bone defects [19]. Such results recently led to attempts to use the (OCHS), alone or under various combinations, in regenerative bony treatment of periodontal defects.

Recently, histological studies in humans indicated that the treatment of chronic periodontal defects with OCHS alone could lead to formation of a new attachment (cementum with inserting collagen fibers) and alveolar bone [20-22]. However, from clinical point of view, some practical problems could arise when using the OCHS alone: the material has a low consistency and, therefore, cannot ensure a sufficient stability of the mucoperiosteal flap, especially in one-wall and circular defects. Frequently, a collapse of the mucoperiosteal flap cannot be avoided, followed by the reduction of the space necessary for the regeneration process [23]. To overcome such problems, the combination of the OCHS with a bone replacement material could offer a convenient solution. By this approach, the chemical and biological properties of the OCHS could be combined with the mechanical properties of the bone replacement materials. In this combination, the OCHS could enhance the bone and the periodontal healing, while the bone replacement material could avoid the collapse of the mucoperiosteal flaps and ensure the post-surgical stability of the wound.

Tricalcium phosphate (TCP) is a promising alternative bone fill material studied and used extensively in the past decades. It is considered to be bioactive (by means of inducing specific biologic reactions) and biocompatible (not stimulating inflammatory or foreign-body giant cell activity). This is mainly because TCP is composed of Ca and P ions, which are the most commonly found elements in bone. However, TCP cements have a slower resorption rate than bone and are usually too dense to allow bone tissue to grow into the defect in a limited period of time. By adding a faster resorbing material, pores may be created, ensuring new bone tissue growing into the defect [24]. β-Tricalcium Phosphate is a highly purified, multi-crystalloid, porous form of the calcium phosphate. It is partially resorbable and is normally used for the repair of non-pathologic sites, in which the resorption of the implant and a replacement by bone is expected [25]. If the healing of the marginal periodontal defects is desired, TCP can provide repair similar to autologous bone [26]. TCP is compatible to the host tissue [27]. The healing of the periodontal wound occurs with bone in growth in the pores of the TCP [28]. Histological analysis of the healing of the defects revealed rather a long-junctional epithelium than a connective tissue attachment [29].

Hydroxyapatite (HAp) has high biocompatibility and good bioaffinity, stimulates osteoconduction, and is slowly replaced by the host bone after implantation [30]. Since early in the 1980s, blocks and granules of porous HAp have been widely used as a bone substitute in the fields of orthopedic, craniofacial, and periodontal regenerative surgical therapy. However, in order to establish an ideal bone substitute to induce new bone, it is necessary that it has a structure with the ability of osteogenic cells being able to easily penetrate deeply into the HAp osseous grafting materials. Recently, superporous HAp has been developed, which has a high level of porosity of 85% [31].

A conclusion of a study of Li Conghua et al. [32] showed that Hydroxyapatite (HAp) can be widely used in the areas of bone restoration and bone substitute. It is effective in the clinical treatment and will be widely used in the bone engineering. The combination of the mechanic properties of the TCP + HAp (OSTEON II) with the biological and chemical features of the OCHS could be both of biologic and clinical interest. So far, there are no clinical data regarding the combined therapy of OCHS and {TCP + HAp} in the treatment of intrabony periodontal defects. The aim of the present study is the assessment of the outcome of periodontal treatment of deep intrabony defects with a combination of **{**(Hydroxyapatite HAp + B-Tricalcium Phosphate granules) (OSTEON II) + oily suspension of calcium hydroxide**}** and compare this treatment modality with open flap debridement (OFD) alone.

MATEIALS AND METHODS

Sixteen patients (10 males and 6 females), between 24 and 45 years old, non-smokers, each displaying at least 2 teeth with deep intrabony defects. For all of the patients, one tooth was treated by OFD only (control group 16 teeth) and the other teeth (study group 16 teeth) were treated with OFD & a combination of granules comprise of (Hydroxyapatite HAp + B-Tricalcium Phosphate) (OSTEON II- Korea) and oily Calcium Hydroxide suspension (Osteoinductal®, Osteoinductal GmbH., Muenchen, Germany). All patients were treated at Al-Mustansiriya University/College of dentistry by the same surgeon at clinics of the department of oral surgery and periodontology. Inclusion criteria for the study were as follows: No systemic diseases which could influence the outcome of the therapy,. Exclusion criteria were: furcation involvement of grade 3 and tooth mobility of degree 3, systemic diseases that required medication affecting periodontium and calcium supplements. Teeth with mobility grade 2 were splinted at least two months before surgery. All patients underwent initial therapy one month prior to surgery. All patients were instructed and motivated to maintain a good oral hygiene level, verified by a reduction of the PLI < 1.

Before surgery and six months after, the following clinical periodontal parameters were registered 1 week prior, then 6 months after the surgical procedure. The plaque index (PLI), gingival index (GI) , bleeding on probing (BOP) , probing pocket depth (PPD), gingival recession (GR) and clinical attachment level (CAL) were measured. The measurements were made at six points per tooth: mesiobuccal (mb), midbuccal (b), distobuccal (db), mesiolingual (ml), midlingual (L), distolingual (dl). The deepest measured point at each surface was used for statistical analysis. The stent margin was used as a fixed reference point for measurement of attachment level . Also pre - and postoperative radiographs were taken using the long-cone parallel technique. There were two parameters analyzed on the radiographs: defect depth – the vertical distance between the bone crest and the site on the root surface at which the periodontium width was normal (in mm), defect width – the horizontal distance between the root surface and bone defect margin in the most coronal part of the bone crest (in mm) [33].

Surgical procedure

Intrasulcular incisions, mucoperiosteal flaps were elevated facially and lingaully. Vertical releasing incisions were made if necessary only in the study group to ensure better wound closure after bone filler placement. After granulation tissue removal from bone defects, roots surfaces were scaled and planed using ultrasonic instruments followed manual instomentation.

In the OFD group after debridement, mucoperiosteal flaps were repositioned and sutured. In study group, before flap closure, intrabony defects were filled with bone substitute material. All patients received antibiotics for one week (3 × 625 mg augmentin per day). Postoperative care consisted of Chlorhexidine (Corsodyl) rinses twice a day for 4 weeks with intervals of stopping rinse among the 4 weeks.

Sutures were removed 14 days post surgery. Recall appointments were scheduled every week during the first month, later, every 3 months. During recall appointments, supragingival plaque was carefully removed with a brush.

Statistical analysis

Statistical analysis was performed with Statistica 10 software (StatSoft, Tulsa OH, USA). For comparison between groups, the non-parametric *U*-Mann–Whitney test was used. For the statistical evaluation of the changes from baseline and 6 months, the paired *t*-test was used, $\mathbf{X^2}$ was used for BOP. Results were considered statistically significant at a *P* value less than 0.05.

RESULTS

Healing was uneventful in all patients. No adverse reactions to bone fill materials were observed. The morphology of treated defects in the majority of cases was 3 wall in both groups. The distribution and configuration of treated defects are demonstrated in (Table 1). There were no differences found in clinical and radiographic parameters of the two groups before treatment. Table 2 & 3 show PLI, GI, BOP, PPD and CAL values (at the base line before treatment & Six months after treatment) in the two groups:

Control group = BOP (96% & 37%), GI (1.23 & 0.71), PPD (6.23 mm & 4 mm) CAL (8.5 mm & 5.1 mm) significantly improved in both groups. The PI value did not change and the GR value showed statistical significant increase after treatment.

Study group = BOP (91% & 10%), GI (1.12 & 0.21), PPD (7.4 mm & 3.5 mm), CAL (8.85 mm & 4.1 mm).

Table 4 demonstrates the analysis of radiographs six months postoperatively which showed a statistically significant reduction in depth and width of bony defects in both OFD group and (OFD + OSTEON & OCHS) group.

Tables 5, 6 & 7 reveal the statistical comparisons between the control & study groups in relation to the amount of improvement (the difference between the baseline & 6 months after treatment) of each parameter in both groups. The comparison between the 2 groups showed that the study group parameters at 6 months after treatment were improved significantly more than those of control group except the PLI in which the difference was statistically not significant.

Table1. Distribution and configuration of bone defects (*n* = 16 for each group)

Defect morphology	Study group	Control group
3 Wall bony defect	12	13
2 Wall bony defect	2	1
1 Wall bony defect	1	1
Circular bony defect	1	1

Table 2: PLI, BOP & GI at baseline and 6 months after treatment

Parameters (Indices)	Treatment group	Baseline	6 months	P- value	Significance
PLI	Control group	0.55 ± 0.31	0.47 ± 0.11	> 0.05	NS
	Study group	0.6 ± 0.21	0.52 ± 0.4	> 0.05	NS
BOP	Control group	96%	37%	< 0.001	HS
	Study group	91%	10%	< 0.001	HS
GI	Control group	1.23 ± 0.25	0.71 ± 0.1	< 0.001	HS
	Study group	1.12 ± 0.23	0.37± 0.3	< 0.001	HS

Table 3: PPD, CAL & GR at baseline and 6 months after treatment

Parameters	Treatment group	Baseline	6 months	P- value	Significance
PPD mm	Control group	6.23 ± 1.1	4 ±1.46	< 0.001	HS
	Study group	7.4 ± 1.9	3.5 ±1.1	< 0.001	HS
CAL mm	Control group	8.5 ±2.4	5.1 ±.5	< 0.001	HS
	Study group	8.85 ± 2.1	4.1± 1.4	< 0.001	HS
GR mm	Control group	2.5 ±0.5	2.9 ± 0.3	< 0.05	S
	Study group	1.8 ±0.8	2.96 ±1.2	< 0.05	S

Table 4: Radiographical parameters at baseline and 6 months after treatment

Parameters	Treatment group	Baseline	6 months	P- value	Significance
Defect depth	Control group	3.9 ± 1.6	3.0 ± 1.3	< 0.05	S
	Study group	4.2 ± 1.2	2.1 ± 1.0	< 0.001	HS
Defect width	Control group	3.56 ± 0.3	2.7 ± 0.7	< 0.01	S
	Study group	3.8 ± 0.6	1.7 ± 0.6	< 0.001	HS

Table 5: Comparison between control & study groups according to the improvement of parameter values (amount of change between the baseline & 6 months of each group)

Indices	Control	Study	T- value	P- value	Sig.
PLI	0.087	0.082	-0.204	0.94	NS
GI	0.5	0.91	9.673	0.0126	S
BOP	59%	81%	X^2=2.933	0.0217	S

Table 6: Comparison between control & study groups according to the improvement of PPD, CAL & GR values (amount of change between the baseline & 6 months of each group)

Parameters	Control	Study	T- value	P- value	Sig.
PPD	2.2	3.9	11.245	0.000	HS
CAL	3.4	4.75	22.783	0.000	HS
GR	0.4	1.16	5.489	0.000	HS

Table 7: Comparison between control & study groups according to the improvement of radiographical parameters (amount of change between the baseline & 6 months of each group)

Radiographical parameters	Control	Study	T- value	P- value	Sig.
Defect depth	0.9 mm	2.1 mm	21.675	0.000	HS
Defect width	0.8 mm	2.1 mm	23.665	0.000	HS

DISCUSSION

Patient age and teeth with osseous defects treated in both study & control groups were similar at baseline. Each subject participating in the clinical investigation demonstrated excellent oral hygiene throughout the entire study. Results from this investigation showed that both treatment procedures, resulted in significant clinical improvement in the treatment of intrabony periodontal defects in all clinical and radiographic bone fill between baseline and 6 months. A variety of graft materials have been widely embraced for being used in periodontal regenerative therapy [34]. Tricalcium phosphate beta (ß-TCP) as a bone graft substitute has been evaluated at length in numerous previous studies. It binds to bone by means of mechanical anchorage with no formation of intermediate apatite layer as well as (ß-TCP) has an important role in GBR procedures, that is, the more solid scaffold of the graft, the more successful the outcome and this property was implemented by the presence of (ß-TCP) in the present study [35]. The findings of the current study have showed that the treatment of deep intrabony defects with (OCHS plus OSTEON II) led to statistically and clinically significant reductions of the periodontal probing depths and clinical attachment level gains in addition to significant reduction of GI, and BOP in both treatment modalities. The results of the current study are in agreement with the findings of Polat et al [36] & Schwarz et al [37] who found promising results resemble those of our study. On the other hand, our results disagree with those of Aparna et al [38], they did not find significant differences between ODF & OCHS). Also the findings of the present study showed that the improvement of the evaluated parameters in the study group is higher significantly than control group at 6 months period of the study. The GI & BOP values were reduced in study group more than control group could be attributed to anti-inflammatory & anti-bacterial properties of the OCHS + ß-TCP in addition to the self plaque control procedures. In relation to methodology, the analysis of the results of treatment with the combination of OCHS + OSTEON could be evaluated with regard to the treatment of intrabony defects by mean of the combination of enamel matrix proteins (EMD) and bovine-derived xenografts or bioactive glasses [39]. There are many similarities between the two therapeutical approaches: both single treatment modalities (OCHS and EMD) are considered to be “biologic”, both products have a fluidity that may require the combination with a bone graft to prevent the collapse of the flaps and both approaches require a good stability of the wound for a favorable outcome [40]. Beta-Tri Calcium Phosphate (ß-TCP) has been documented so far in a clinical study that has found average PPD reductions of 2.42 ± 2.50 mm & CAL gains of 1.25 ± 2.22 mm at 6 months after the treatment of intrabony defects [41].

On the other hand, treatment of intrabony defects with OCHS alone resulted in an average PPD reduction of 5.33 ± 1.40 mm and a CAL gain of 4.4 ± 1.40 mm CAL. So, the average CAL gains & PPD reductions achieved by OCHS are higher than those obtained by using the β-TCP alone [42,43]. These results should probably be compensated by the stability of the wound achieved primarily by using the combination OCHS + OSTEON and by increased resorption capacity of the OSTEON. The relatively marked CAL gain noted in this study could testify for the wound-stabilizing effect of the bone replacement material and could emphasize the clinical relevance of the combined therapy. The already described biological and clinical characteristics of OCHS and OSTEON could offer some practical advantages in deep defects when compared with the GTR-technique or with the combination of GTR plus a bone replacement material, when an exposure of the membrane could be a major inconvenient. The combination of OCHS and OSTEON could enhance the improvement of wound healing as well, as reported by the postoperative evolution of the cases. No complications as abscesses or infections occurred postoperatively. However, the effect of the antibiotics on this particular positive outcome cannot be excluded. Antibiotics are being prescribed in most of the clinical studies on regenerative periodontal therapies; however, the literature has no defined position on the influence of the antibiotic adjunctive postoperative medication [44]. More clinical controlled studies are needed to determine the necessity of postoperative antibiotics following regenerative periodontal treatments. More histological studies are also needed in order to determinate if the observed clinical results represent a true periodontal regeneration rather than a simple defect fill.

As a conclusion, the results of the current study showed that treatment of deep intrabony defects using an OCHS combined with OSTEON II resulted in a statistically and clinically significant reduction of the GI, BOP, PPD and CAL gain and reduction of the size of the treated intrabony defects. The absence of allergic or infectious reactions indicates that the combination of the two materials is stable and well tolerated, in addition to the benefits from the anti-inflammatory and possible osteostimulative action of the Oily Suspension of Calcium Hydroxide. The use of OSTEON II was beneficial due to its roles in serving as scaffold for OCHS and its osteoinductive activity.

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