
A comparative clinical study of solid and granular porous hydroxylapatite implants in human periodontal osseous defects

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Solid and granular porous hydroxylapatite implants were compared in the surgical treatment of angular interproximal periodontal defects in 10 subjects. After completion of initial therapy, presurgical measurements of pocket depth, attachment level, gingival recession, gingival fluid and tooth mobility were recorded. Six months after the surgery the measure-

ments were repeated. The use of both forms of porous hydroxylapatite resulted in reduction in pocket depth, and probable attachment level gains as well as gingival recession and reduction of gingival fluid and tooth mobility. These changes were similar for both granular and solid forms of porous hydroxylapatite.

Porous prosthetic materials composed of metals and thermoplastics have been developed by the replication of the skeletal structure of marine invertebrates.¹ This technology has been utilized to produce a porous hydroxylapatite replicate (Interpore 200*) of the reef building coral *Porites*.² This material is available in blocks and granules and has an internal structure composed of interconnecting pores of 190 to 230 μm in diameter (Figs. 1 and 2). The hydroxylapatite of Interpore 200 is in the form of small crystals³ which have a much larger surface area than the large fused crystals seen in the sintered nonporous types of artificial hydroxylapatite⁴ (Fig. 3). When this porous hydroxylapatite is implanted in contact with bone there is an initial ingrowth of connective tissue and blood vessels, which leads to the deposition of bone along the walls of the pores.^{5,6}

Implantation of porous hydroxylapatite in dog mandibular defects,^{7,8} as onlays on dog mandibles,⁹ and in long bone defects of dogs and rats¹⁰⁻¹² has confirmed the ability of this material to stimulate bone formation. Periodontal osseous defects in dogs respond to porous hydroxylapatite implants in the same manner, with connective tissue infiltration leading to bone formation within and around the implant.¹³

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Clinical trials using porous hydroxylapatite to treat angular interproximal defects have demonstrated significant reductions in pocket depths, significant attachment level gains and significant fill of the osseous defect.¹⁴ The material was implanted in a solid form. Similar trials with Class II furcation defects have shown that a combination of solid porous hydroxylapatite together with granules of the same material also lead to pocket depth reduction, attachment level gains and fill of osseous defects.¹⁵ In both clinical trials the use of porous hydroxylapatite was significantly superior to control defects treated with the same surgical technique but with no hydroxylapatite implants.

Tissue samples taken from human periodontal defects treated with porous hydroxylapatite implants have demonstrated bone formation in both granular and solid forms of this porous material.¹⁶ Block sections from human subjects have also shown bone ingrowth into and around both forms of porous hydroxylapatite.¹⁷

The granular form of porous hydroxylapatite has not been evaluated in the treatment of human interproximal defects. The granules provide the advantage of being technically simpler to utilize compared to the use of block material that is custom shaped to fit the defect at the time of surgery. It is possible that granules will give a more complete spatial fill of the depths of an osseous defect than would a solid piece, particularly if the defect is complex in shape. On the other hand, clinical experience with other granular hydroxylapatites shows that some of the surface granules are exfoliated during the initial healing period.

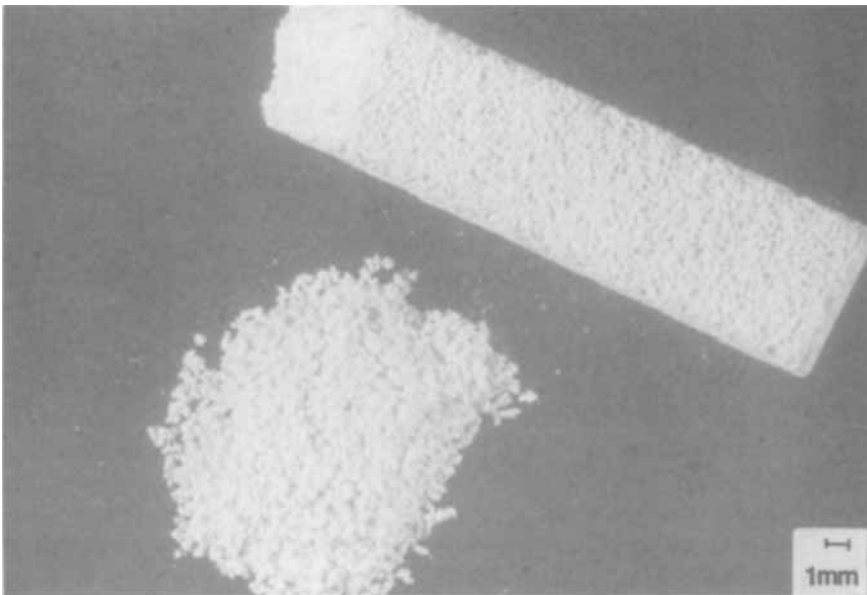


Figure 1. Solid and granular form of porous hydroxylapatite.

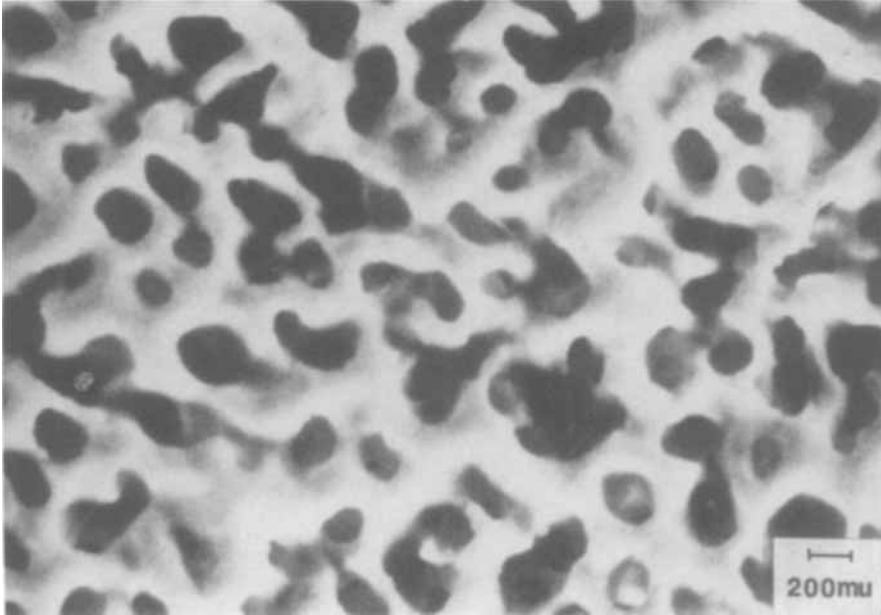


Figure 2. Scanning electron photomicrograph of porous hydroxylapatite. The interconnecting pores are seen cut in cross section and obliquely.

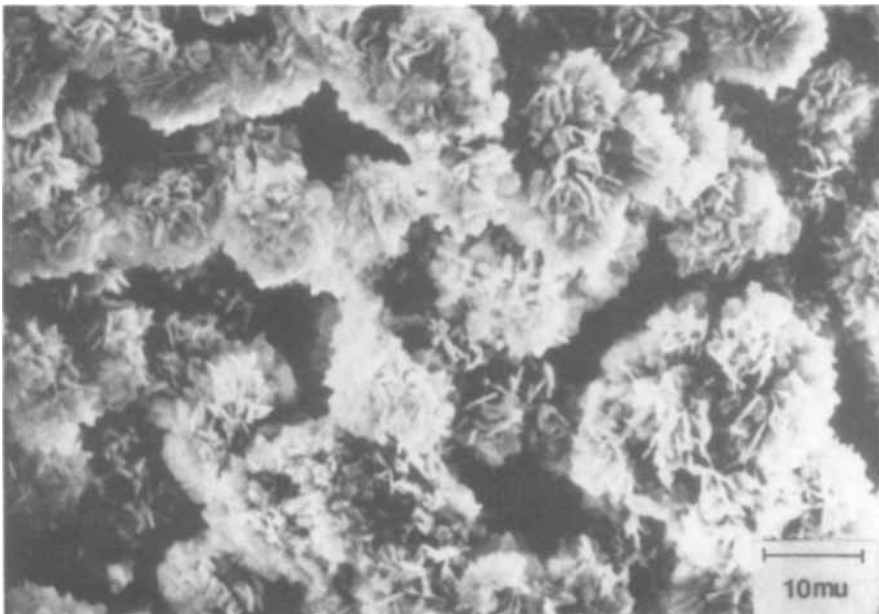


Figure 3. Scanning electron micrograph of fine structure of porous hydroxylapatite. Note the large surface area of the crystalline structures.

Therefore the present study was designed to compare the clinical effectiveness of granular and solid forms of porous hydroxylapatite in the treatment of interproximal angular intrabony defects associated with human periodontal disease.

MATERIALS AND METHODS

Ten subjects, with a mean age of 33.8 ± 8.8 years, were used in this study. Each subject had at least two interproximal angular periodontal defects with initial pocket depths of 6 mm or more. All patients were free of systemic disease and were not utilizing any medications during the time of treatment.

Initial therapy was instituted prior to the surgical procedures. This initial therapy included oral hygiene instruction, root planing with local anesthesia, treatment of active carious lesions, and occlusal adjustment if trauma from occlusion was present.

Presurgical measurements were taken at least 5 weeks after completion of initial therapy and immediately prior to the surgery. The following parameters were recorded.

(1) Pocket depth and attachment levels were recorded for the deepest probeable region of the interproximal defect. An occlusal acrylic stent with grooves was made for each subject to give a reproducible placement of the probe (Fig. 4). Attachment levels were recorded from a fixed point on the stent while the gingival margin was used to measure pocket depths. Gingival recession was measured as the distance from the stent to the tip of the interdental papilla.



Figure 4. Presurgical view. Pocket on mesial of upper first premolar showing use of stent and groove to locate periodontal probe.



Figure 5. Presurgical radiograph of patient. Intrabone defects were present on the mesial of the first premolar and mesial of first molar.

(2) Gingival fluid measurements of the interproximal pockets were made using filter paper strips placed at the orifice of the pocket. The strips were stained with ninhydrin and the length of wetted area was measured in millimeters.

(3) Tooth mobility was evaluated on a scale of 0 to 5. Teeth were displaced faciolingually utilizing the metal handle of a mouth mirror and a score of 1 was used for 0 to 0.5 mm movement, 2 for 0.6 to 1.0 mm, 3 for 1.1 to 1.5 mm, 4 for 1.6 to 2.0 mm and 5 for movement greater than 2.0 mm.

At the time of surgery one defect in each subject was randomly assigned for implantation with granular porous hydroxylapatite and another for implantation with solid material (Figs. 5 and 6). The granular material had a particle size of 425 to 600 μm , and in all implanted sites the hydroxylapatite was packed into the defect so that it slightly underfilled the defect. Implanted material was kept at least 0.5 mm apical to the most coronal level of the crestal bone.

The surgical procedure used to expose the interproximal defects was carried out under local anesthesia. Sulcular incisions were used to initiate the elevation of full thickness mucoperiosteal flaps. Granulation tissue was removed to expose the boundaries of the osseous defects and to allow access to the root surfaces. Root surfaces were smoothed with hand instruments. The hydroxylapatite implants were placed in the designated sites and the flaps were repositioned as close as possible to their original level. Silk sutures were placed to maximize flap closure and a periodontal dressing was applied to the area (Fig. 7).



Figure 6. Palatal view at time of flap surgery. Solid hydroxylapatite has been placed on mesial of first premolar and granular hydroxylapatite has been placed on mesial of first molar.



Figure 7. Mattress sutures placed to give maximal wound closure over hydroxylapatite implants.

Postoperative medication included the use of oral analgesics as required and a seven day course of oral antibiotics. Penicillin or erythromycin were used in the dosage of 250 mg four times per day. One week postoperatively the sutures were removed and the dressing replaced. Two weeks postoperatively, the dressing was removed and oral hygiene instructions were repeated.

After 3 months each patient was seen for a routine recall appointment at which time the surgical areas were gently curetted supragingivally and a rubber cup polishing was completed. Oral hygiene instructions were emphasized for all participants.

Six months after the surgery each of the presurgical measurements was repeated (Figs. 8 and 9). These data were used to compare the results of the treatment procedures. Comparisons of changes in clinical parameters within each treatment modality were tested using the Student *t*-test for correlated measurements. Comparisons of changes between the two treatment modalities were also evaluated with the *t*-test.

RESULTS

In the 10 subjects a total of 20 bony defects were treated. All surgical areas healed without any complications. There were no postoperative infections and no obvious areas of flap necrosis.

The results of pocket depth measurements are seen in Table I. All sites showed clinical and statistical significant post surgical reduction of pocket



Figure 8. Six months postsurgical radiograph showing hydroxylapatite filling the osseous defects.

TABLE I
Pocket Depth Measurements (mm)

	Presurgical	6 Months Postsurgical
Granular implant	7.13 ± 2.29*	2.92 ± 1.04
	NS	NS
Solid implant	7.55 ± 1.49*	2.31 ± 1.94

NS = No statistically significant difference.

*Statistically significant difference $p \leq 0.001$.

depths. While the solid implanted sites showed a slightly greater pocket depth reduction than the granular sites this difference was not statistically significant.

Attachment level changes followed a similar pattern to pocket depth changes (Table II). The 6 month postsurgical levels were significantly reduced for both treatment methods. The solid sites had the larger change in attachment level but the change was not statistically significantly better than that seen in the granular implanted sites.

Gingival recession recordings demonstrated that both solid and granular groups had postsurgical gingival recession averaging less than 2 mm. There was no significant difference between the groups (Table III).

Gingival fluid measurements showed a significant reduction post surgery in both implanted groups. There was no apparent difference between the solid and granular implanted sites (Table IV).

Tooth mobility measurements showed statistically significant changes in both of the groups when presurgical measurements were compared with postsurgical results. However, these changes were small in magnitude (Table V).

TABLE II
Attachment Level Changes (mm): Presurgical versus 6 Months Postsurgery Measurements

	Granular Implant		Solid Implant
Mean	2.64	NS	2.95
Standard deviation	2.66		1.03

NS = No statistically significant difference.

TABLE III
Gingival Recession Changes (mm): Presurgical Versus 6 Months Postsurgery Measurements

	Granular Implant		Solid Implant
Mean	1.90	NS	1.71
Standard deviation	1.26		0.82

NS = No statistically significant difference.

TABLE IV
Gingival Exudate Scores: Presurgical Versus 6 Month Postsurgical Measurements

	Presurgical		6 Month Postsurgical
Granular implant	7.73 ± 2.21	*	4.62 ± 3.53
	NS		NS
Solid implant	7.00 ± 2.02	*	4.72 ± 2.31

*Statistically significant difference $p \leq 0.02$.

NS = No statistically significant difference.

TABLE V
Tooth Mobility Scored 0 to 5: Presurgical Versus 6 Months Postsurgery Measurements

	Presurgical		6 Month Postsurgical
Granular implant	2.31 ± 1.06	*	1.74 ± 1.06
	NS		NS
Solid implant	2.62 ± 0.84	**	1.80 ± 0.79

*Statistically significant difference $p \leq 0.05$.

**Statistically significant difference $p \leq 0.01$.

NS = No statistically significant difference.



Figure 9. Six months postsurgery clinical view. The gingival tissues are normal over the implanted sites and there has been no recurrence of periodontal disease in these areas.

DISCUSSION

All sites showed clinical improvement six months after periodontal surgery, demonstrating the value of surgical intervention for treatment of advanced periodontal disease. These areas implanted with porous hydrox-

ylapatite healed normally and confirm that this material is well tolerated by periodontal tissues. The reduction in pocket depth and improvement of clinical probeable attachment level seen in both granular and solid implanted areas showed that both forms of this porous hydroxylapatite have a similar clinical course after periodontal surgery. Any differences seen between these two forms were statistically and clinically insignificant. The changes in pocket depth and attachment level seen in the present study were similar to that reported previously with the use of solid porous hydroxylapatite,¹⁴ confirming the value of this technique for treating interproximal defects.

A previous report¹⁸ of a similar clinical study utilizing nonporous sintered hydroxylapatite showed 6-month postsurgical pocket depth reductions of 2.0 mm and 1.8 mm for experimental and control areas with pocket depths 6 mm or greater; and attachment level gains of 1.0 mm and 0.8 mm, respectively, with no apparent statistical difference between implanted and nonimplanted sites. In contrast previous studies^{14,15} utilizing porous hydroxylapatite have shown significant differences in the above mentioned parameters when implanted sites were compared with nonimplanted sites.

The reduction in gingival exudate demonstrates that gingival inflammation has been reduced by the surgical therapy. Tooth mobility was less after the surgery, however, the changes seen were relatively small and the methods used for mobility measurements are quite subjective. Therefore, it is difficult to be sure that the reported differences are clinically important.

It is not possible to determine the histological changes associated with the present study. Improvements on probeable attachment levels may be related to reduction of inflammation, presence of a long well adapted junctional epithelium or to reconstitution of periodontal fibers and cementum. In any case the results show that a granular form of porous hydroxylapatite gives similar clinical results to a solid form of this material. Therefore the use of granular porous hydroxylapatite can be recommended for the surgical treatment of interproximal angular defects.

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