Augmentation of the atrophic maxillary alveolar ridge with hydroxyapatite granules in a Vicryl (Polyglactin 910) knitted tube and simultaneous open vestibuloplasty

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SUMMARY. A modified technique for augmentation of the severely atrophic edentulous maxillary alveolar ridge is described. The augmentation was carried out using a knitted polyglactin 910 mesh tube filled with porous hydroxyapatite granules, the tube being inserted through the access achieved by an open vestibuloplasty.

The results of an in-vivo animal study showed that the absorption of the mesh was complete between 49 and 70 days. The clinical study included 11 patients in all of whom there was severe maxillary ridge atrophy and major prosthetic problems; follow-up was for a mean of 25 months. The procedure was without significant complication and produced a mean immediate absolute augmentation of 5.5 mm and substantially increased vestibular depth. A gradual reduction of ridge height was found over time. Nevertheless all patients showed significantly increased ability to wear their dentures. The technique is presented as a safe and predictable alternative to the use of bone grafts and titanium implants in these severely atrophic cases.

INTRODUCTION

The development of osseointegrated implants has revolutionised the prosthetic rehabilitation of the totally and partially edentulous patient. The relative importance of the various techniques in the armoury of the preprosthetic surgeon therefore has changed dramatically. However, not all patients can be treated with such implants and the use of implants with bone grafting (with or without osteotomies) is not always appropriate. Developing and perfecting alternative techniques, therefore, remains an important task in the field of preprosthetic surgery.

A technique for augmentation with simultaneous open vestibuloplasty of the severely atrophic maxillary alveolar ridge, a modification of that described by Härle and Kreusch is presented. An in vivo animal study on knitted polyglactin 910 tubes and the clinical results of the augmentation-vestibuloplasty are described.

METHOD AND MATERIALS

The study consisted of two parts:

1. An in-vivo evaluation of Vicryl* (polyglactin 910) knitted mesh

The mesh was implanted intramuscularly into rats for up to 91 days in order to assess both tissue reactivity and the absorption profile of the material.

A total of 18 male SPF rats (Nottingham University) were used. In all animals, a sample of the knitted mesh was placed in a small pouch made in the lumbar muscle on either side of the midline. The rats were divided into nine groups with 2 rats per group, the survival period per group being respectively 3, 7, 14, 21, 28, 35, 49, 70, 91 days.

At the end of the survival period the rats were killed with CO₂. The implants with surrounding tissue were excised and fixed in neutral buffered formalin before being processed for routine wax histology.

2. A clinical evaluation of the use of an augmentation/open-vestibuloplasty

This was carried out in 11 patients, all of whom demonstrated severe (Class V and VI) maxillary alveolar ridge atrophy. 6 women and 5 men, were incorporated in the study. 7 patients exhibited class VI alveolar resorption and 4 patients class V. The mean age at operation was 60 years with a range of 45–74 years. 2 patients were in their 5th decade, 3 in their 6th, 3 in their 7th and 3 in their 8th. The follow-up period ranged from 12 to 65 months with a mean of 25 months.

For the augmentation of the maxillary alveolar ridge, porous hydroxyapatite granules (Interpore 200®) were inserted in an 8 mm diameter Vicryl* (polyglactin 910) knitted tube (Ethicon GmbH, Hamburg) so as to prevent migration in unwanted directions. If a flabby ridge was present, this was excised or radically reduced 1–3 months earlier.

The procedure started with the development of a palatally pedicled mucosal flap from the inside of the lip to the alveolar crest (Figs 1A & B). The dissection commenced at a submucosal level but entered a
subperiosteal plane 2–4 mm cranial to the alveolar crest. The subperiosteal dissection continued over the crest and onto the palate. The width of the flap was usually from second premolar to second premolar but was occasionally extended posteriorly if required though with careful avoidance of damage to the parotid ducts.

Once this flap had been raised, the muscles attached to the alveolar ridge were sharply dissected cranially preserving periosteal bone coverage and thus creating a sulcus. A 2 mm cuff of this cranial periosteum was raised to permit later suturing. Care was taken to avoid any communication with the nasal cavity.

The length of the ridge to be augmented was estimated. At one end of an 8 mm-diameter Vicryl (polyglactin 910) knitted tube, a Vicryl (polyglactin 910) suture was tied and the needle retained. This tube was then filled with the HA-granules and tied at the other end with a similar suture (Fig. 2A). The filled tube was then introduced to the alveolar ridge with the aid of the two sutures which were tied posteriorly to the crestal mucosa, ensuring that the tube was lying clearly on bone (Fig. 2B). The previously raised mucosal flap (part of which was mucoperiosteal) was then folded over the tube and sutured to the cranial periosteal cuff, ensuring complete coverage of the tube (Fig. 2C).

The de-epithelialised area of the lip was dressed with ribbon gauze soaked in Whitehead’s Varnish and retained by a continuous silk suture from palatal to labial mucosa. This was retained for 2 weeks during which secondary epithelialisation took place. As an alternative, in two cases a split skin graft was placed and quilted with sutures and perforations to cover the defect. No splint was used and denture wear was avoided during the first 3 weeks postoperatively in order to prevent mucosal dehiscence with consequent exposure of the mesh and HA granules.

During the healing period, it was possible to make minor adjustments in the position and shape of the tube digitally. After three weeks a temporary denture was constructed with a soft lining. Subsequently, a definitive denture(s) was constructed using standard prosthetic procedures with careful periphery development before registering the final impression. The occlusion was arranged so that balance was achieved in function to ensure no disturbing contacts were produced. A split cast processing technique was used and the occlusion was always refined at insertion.

All patients were managed by the same surgical-prostodontic team and were assessed and followed-up in a combined clinic. Lateral cephalograms and orthopantomograms were taken pre- and postopera-

Fig. 1A – The atrophic maxillary alveolar ridge in cross-section.
Fig. 1B – The augmentation/vestibuloplasty in cross-section.

Fig. 2A – Knitted mesh tube filled with hydroxyapatite granules.
Fig. 2B – Tube in position on the maxilla.
Fig. 2C – Mucosal flap sutured over the tube.
RESULTS

1. Animal study

At 3 days the reaction area comprised a loose matrix of fibrin, polymorphs and a few macrophages and fibroblasts. The Vicryl (polyglactin 910) filaments were dispersed throughout the reaction area with developing granulation tissue round the edges.

By 7 days the mesh was surrounded and infiltrated by granulation tissue comprising macrophages, giant cells, polymorphs and fibroblasts with host collagen deposition around and within the reaction area. The 14 days sections showed more host collagen deposition and the cut surfaces of the filaments beginning to crack.

Vascularisation of the granulation tissue started at 21 days, and at 28 days the surrounding collagen capsule was more distinct, as were thin bands of collagen running between the mesh filaments within the granulation tissue. Absorption of the mesh was ongoing as highlighted by the cracking but also by the filaments turning yellow.

By 35 days the majority of the filaments were still yellow and cracked but in each section there were pinkish stained filaments without defined edges, evidence of continued absorption. The overall size of the implanted mesh had decreased by 49 days. The filaments were noted at different stages of absorption, some yellow, some pinkish and others completely absorbed.

By 70 days the absorption of the Vicryl (polyglactin 910) was complete, small hypercellular areas being all that remained. In a few 91 day slides the original site of implantation was marked by an area of collagen interspersed with aged and pigmented macrophages.

2. Clinical study

The mean edentulous period for the patients was 30 years (range 17 to 47) during which an average of 8 sets of complete dentures had been constructed (range 1 to 20). Prior to surgery, 10 out of 11 patients complained of pain and discomfort, all had difficulty in eating, all complained of loose dentures, 2 had recurrent ulcers and 1 patient had difficulty in talking (described as the denture flying across the room while speaking). Nevertheless all patients wore their denture all day, 7 patients even all night.

For all patients denture wearing became less problematic after the operation and this was maintained throughout the period of the study. 8 patients described the result as excellent, 2 found it much better and 1 felt some improvement. 8 patients could eat the foods they wished to though 3 had difficulty with tough, fibrous or hard foods. All patients said the operation was worth the discomfort and 9 patients would undergo the same procedure again. Regarding the complaints or problems as a result of the operation, 3 patients mentioned some sensory deficit in the area of the infraorbital nerve and 2 patients intermittently felt some soreness of the mucosa overlying the HA. For 9 patients there was an improvement in their social life, for the other 2 there was no change. 3 patients even mentioned a positive change in their personality. As for changes of facial profile, 2 patients found this to be better, 5 marked no change and 4 found it worse, mostly regarding some changes in the upper lip.

Postoperatively, early dehiscence of the mucosa was noted in 3 cases. The dehiscences were small and healed within a few weeks without intervention or loss of HA granules. No late dehiscence occurred in any of the patients even under denture loading. In one of the two patients who received a skin graft, the donor site was slow to heal and caused pain for 3 months. No obvious benefit was conferred by skin grafting and all subsequent cases were allowed to epithelialise secondarily.

The latest prosthetic follow-up revealed the following results. The denture aesthetics were acceptable in 9 of the 11 patients; in the remaining two this was subsequently corrected. All dentures showed good retention, 9 showed good stability and in 2 cases denture stability was poor. The vestibular depth was very good in 5 cases, good in 4 and satisfactory in 2 cases (Fig. 3).

The insertion of the HA resulted in a mean immediate absolute augmentation of 5.5 mm (Fig. 4). No difference was found between the anterior and posterior region. Over time this augmentation gradually decreased. After 6 months the mean augmentation was 4.5, after 12 months 3.5, after 24 months 3.0, after 36 months 2.0 (with a range of 1–4 mm at this stage). The one patient who was followed-up for 65 months still had at the last review an augmentation of 4 mm.

DISCUSSION

Many experimental and clinical studies have proved the excellent biocompatibility of the hydroxyapatite ceramics (HACs). Several names have been used to describe their biological properties including bioactive, osseoinductive, osseoconductive. Despite the findings of Kenney et al., extensive morphological studies have shown HACs to have no bone-inducing properties. Instead, when the HA is stable the bone will grow in direct contact with it with a substantial amount of bone ingrowth as well as bone coverage of the implant matrix. In that respect the porous HAs (Interpore 200, Osprovit) give more...
stability than the non-porous ones (Allotropat 50, Calcitite 2040, Durapatit) due to ingrowth of bone in the pores. A certain amount of resorption of the ceramics does occur, the products that arise (calcium- and phosphorus ions) taking part in the physiological turn-over of the bone. Therefore, HACs can be seen as bioactive, osseoconductive materials. Resorption of the HA seems to take place especially after a period of two years. In augmentation procedures, stability of the implant material used is of the utmost importance. Use of HA-particles has the drawback of unwanted migration but the use of a Vicryl (polyglactin 910) knitted tube to stabilise the granules until encapsulation has occurred has been shown to be an excellent method of containment.

Vicryl (polyglactin 910) is prepared from a glycolide: lactide copolymer in the ratio 90/10. The animal study cited showed that in rats the absorption of the material is complete between 49 and 70 days, which conforms with other studies. Special concern of clinical relevance includes the bony ingrowth of the HA-particles despite the initial presence of mesh between the bone and the HA, and despite the additional inflammatory reaction that Vicryl (polyglactin 910) induces. Merten et al have shown that the bony integration of the HA is not influenced by the presence of the tube. A form-stable implant results, bony integrated at the base and ingrown with connective tissue at the mucosal side.

The favourable biological characteristics of HA in combination with a Vicryl (polyglactin 910) tube stimulate the use of it for augmentation procedures. This is supported by the good clinical results. Beck-Mannagetta et al found that after augmentation of 19 maxillary alveolar ridges all patients were satisfied with the result. Their follow-up period ranged between 3 and 32 months (mean 13 months). No instability or dislocation of the material was found and small dehiscences postoperatively healed without problems. Others have found the same favourable results.

Härle et al presented their technique and results of augmentation with HA in a Vicryl (polyglactin 910) tube on 118 patients, 64 being carried out in the maxilla. The augmentation was combined with a submucous vestibuloplasty. For this a splint was used, fixed in 20 maxillary cases with a lag screw in the palate. During the study the protocol was changed as the use of a fixed splint for a prolonged period caused local pressure necrosis of the mucosa (in 14 of the maxillary cases), which nevertheless epithelialised by secondary intention. The fixed splint was used subsequently for only 24 h. It was replaced by a newly constructed removable one. In the most recent report of their cases, Kreusch reported only a small number of complications. In 3 cases the operation had to be repeated due to dislocation of the tube. In one case a secondary infection of the HA by Actinomycetes species was found. A continuous reduction of the height of the augmented ridges was measured. Their best results occurred in the maxilla.
and they concluded that augmentation of the maxilla in this manner is a safe technique with predictable and good results.

The study reported here was confined to the maxilla, the authors considering that the various titanium and transmandibular implant techniques are suitable for virtually all mandibular problems. It showed similar very favourable results. The tube effectively prevented migration of HA particles in the critical initial weeks after surgery, the augmentation was stable and it gave good retention and stability for the prosthesis. This was accompanied by high patient satisfaction and a low incidence of complications. The use of an open vestibuloplasty made accurate placement of the tube easier and the sulcus gain achievable was much greater. The avoidance of any form of splint is not only more comfortable for the patient but also reduces significantly the risk of pressure necrosis of the soft tissues and thus avoids wide exposure of HA granules. A continuous reduction of the height of the augmented ridge, however, is seen. It is not quite clear whether this is due to impaction or resorption of the HA, resorption of the basal bone or a combination of all of these. The need therefore for regular prosthetic review and relining of the dentures when necessary is emphasised.

CONCLUSION

Augmentation of the severely atrophic maxillary alveolar ridge with HA in a Vicryl (polyglactin 910) tube combined with simultaneous open vestibuloplasty is a safe and predictable technique which gives good retention and stability for the prosthesis. An essential difference between this technique and others is the way the gain in height is supplemented by substantial deepening of the vestibular sulcus, essential for the construction of a functional prosthesis. In contrast with Härel et al who used a submucous vestibuloplasty and Beck-Mannagetta et al who used skin-grafting in a second stage, the use of an open vestibuloplasty also enables direct visualisation of the ridge and thus correct positioning of the tube. The dissection of the vestibuloplasty is more accurate, achieves a greater sulcus depth, avoids the use of a splint and permits a one stage surgical procedure.

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