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Flap prefabrication using high-density porous polyethylene in an animal model – an experimental study

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Study Design A
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Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
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Background: The search for new surgical flap techniques and modifications of already existing ones is gaining increasing popularity. Progress in flap designing and harvesting have improved the functional and aesthetic results, especially in head and neck reconstruction.





Material/Methods: Ten pigs were used in this study. In the first operation, high-density porous polyethylene prefabrication was performed bilaterally in all pigs. After 8 weeks, each prefabricated complex was explored, resected, and macroscopically evaluated.

Results: All of 20 prefabricated flaps survived. No serious surgical complications were observed. In 2 cases there was chronic inflammation and in 4 cases there was instability of the implant.

Conclusions: After this experimental study, we believe that the use of high-density porous polyethylene in flap prefabrication may be a good option for reconstruction of 3-dimensional defects, especially in patients with limited donor tissues.

Key words: **flap prefabrication • free flap • reconstruction**

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Background

For the last 30 years free flap reconstructive surgery has become routine, while basic principles of microsurgery have changed very little. The search for new techniques and modifications of already existing ones is gaining increasing attention. Progress in flap designing and harvesting have improved the functional and aesthetic results, especially in head and neck reconstruction. Surgical technique has shifted from simply obtaining flap survival and wound coverage, to better flap selection and more sophisticated reconstruction, due to the possibility of making the transfer of thinner flaps, flaps matching the recipient site's color and texture, and complex flaps for 3-dimensional reconstructions. Therefore, the recent idea of flap prefabrication offers new hope for experimental research.

Flap prefabrication is defined as implantation of separated vascular pedicle in a new territory, followed by a transfer of the flap neovascularized by this pedicle. These flaps are mainly used in head and neck reconstruction to achieve similar texture, shape, and color to those of recipient site; however, prefabrication is usually reserved for individual cases in which conventional techniques are unreliable or unavailable. Prefabrication is the process of making flaps to fulfill specific requirements by designing them with only required components in new vascular areas while minimizing donor site morbidity [1,2]. Instead of secondary corrections for a standard flap, the prefabricated complex is finished before the final free flaps stage is entered. Vascular induction by implantation of a pedicle allows designing the flaps in discrete donor sites or in areas of skin excess. It is possible to establish new flaps with any desired components from anatomical regions that do not have defined axial vessels. Prefabrication allows almost any tissue volume to be transferred to any specified recipient site, thus expanding the options of microsurgical reconstructions [3,4].

Autologous cartilage and bone are commonly used as a framework in reconstructive surgery. However, their disadvantages (e.g., limited availability and the morbidity and high risk of resorption) are quite serious. The advantages of microporous materials include decreased specific implantation weight and absence of capsular reaction. Porous high-density polyethylene is an alloplastic material used by surgeons for over 50 years, and it has been shown to be well tolerated [5]. It induces a minimal reaction when implanted into human tissues, and fibrovascular tissue not only anchors the implant but also imparts certain biological qualities to the implant, including the availability to support neopithelialization and skin grafting. The main advantage of PTFE is the interweaving and ingrowth of loose connective tissue and vasculature [6,7]. The technique of flap prefabrication is illustrated in Figures 1 and 2

Material and Methods

Ten pigs were used in this study. General anesthesia was administered to all of them. Prophylactic Augmentin was also administered intraoperatively to all of the animals. The inferior epigastric artery and vein were chosen as vascular carriers because of ease of dissection and sufficient diameter. In the first operation, high-density porous polyethylene prefabrication was performed bilaterally in all pigs. After 8 weeks, each prefabricated complex was explored, resected, and macroscopically evaluated. The samples obtained for histopathologic study were fixed in 10% formaldehyde solution for 24 h. The tissues were routinely processed and embedded in paraffin blocks and 5-um-thick sections were obtained and evaluated microscopically (Figure 3). The research protocol for this investigation was approved by the local ethics committee.

Results

All 20 prefabricated flaps survived and no serious surgical complications were observed. In 2 cases there was chronic inflammation and in 4 cases there was instability of the implant. Nearly 90% of the pores were invaded by soft tissue after 8 weeks. In some areas, the fibrovascular tissue invading the pores had reached up to the outer surfaces of the implant. The inner parts of the implant were invaded with more mature and loose connective tissue compared with newly vascularized outer parts. Inflammatory cells and active fibroblasts were present in some spots where the fibrovascular tissue formation was taking place.

Discussion

Flap prefabrication was used for the first time in 1971 by Orticochea, who described vascular implantation in the retroauricular region for delayed nasal reconstruction. The introduction of a new blood supply into subcutaneous territory in an attempt to create new vascularized flaps was first described by Washio, who implanted a section of pedicled dog intestine into the abdominal skin. Other authors have used skin grafts placed over axial vessels or arteriovenous fistulas [8,9]. Those experimental studies were based on the theory that thin skin flaps can be created based on implanted vascular pedicles. Voy reported an application of Proplast II for framework for prefabricated flaps, covering the implant with omentum and a skin graft. Fisher and Wang reported the same procedure of prefabrication of the ear and penis. This pioneering research stimulated many investigators to consider the possibility of creating custom-designed donor sites by implantation of a nourishing vascular pedicle in the target tissues prior to harvest [10,11]. This vascular carrier could be mesenteric vascular pedicle, vascular

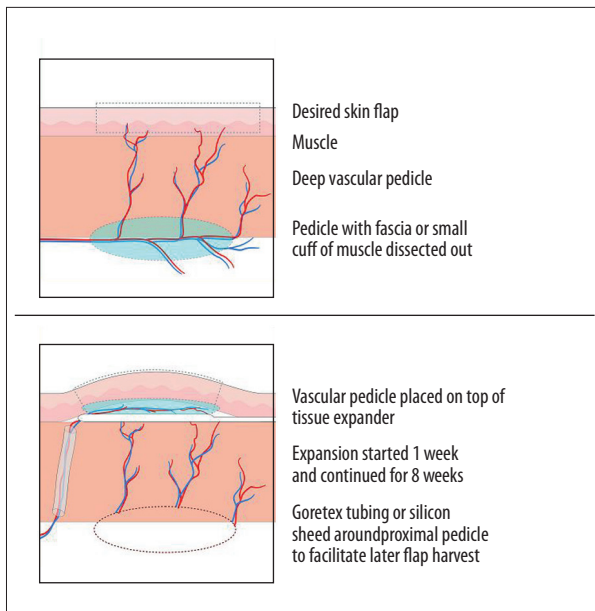


Figure 1. Technique of flap prefabrication.

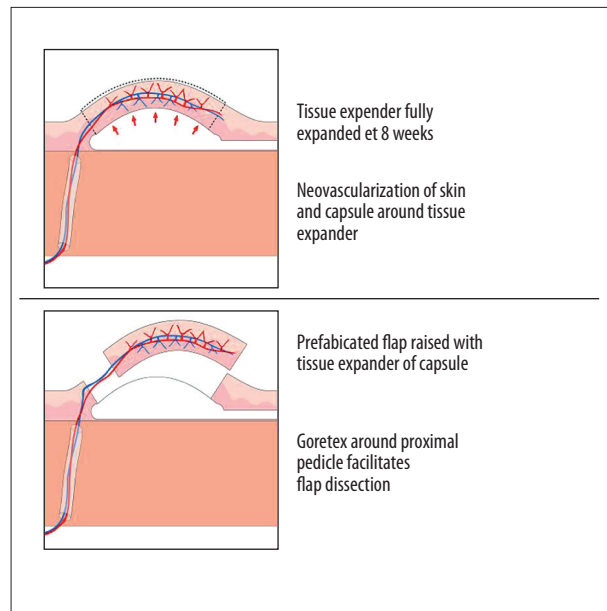


Figure 2. Technique of flap prefabrication.

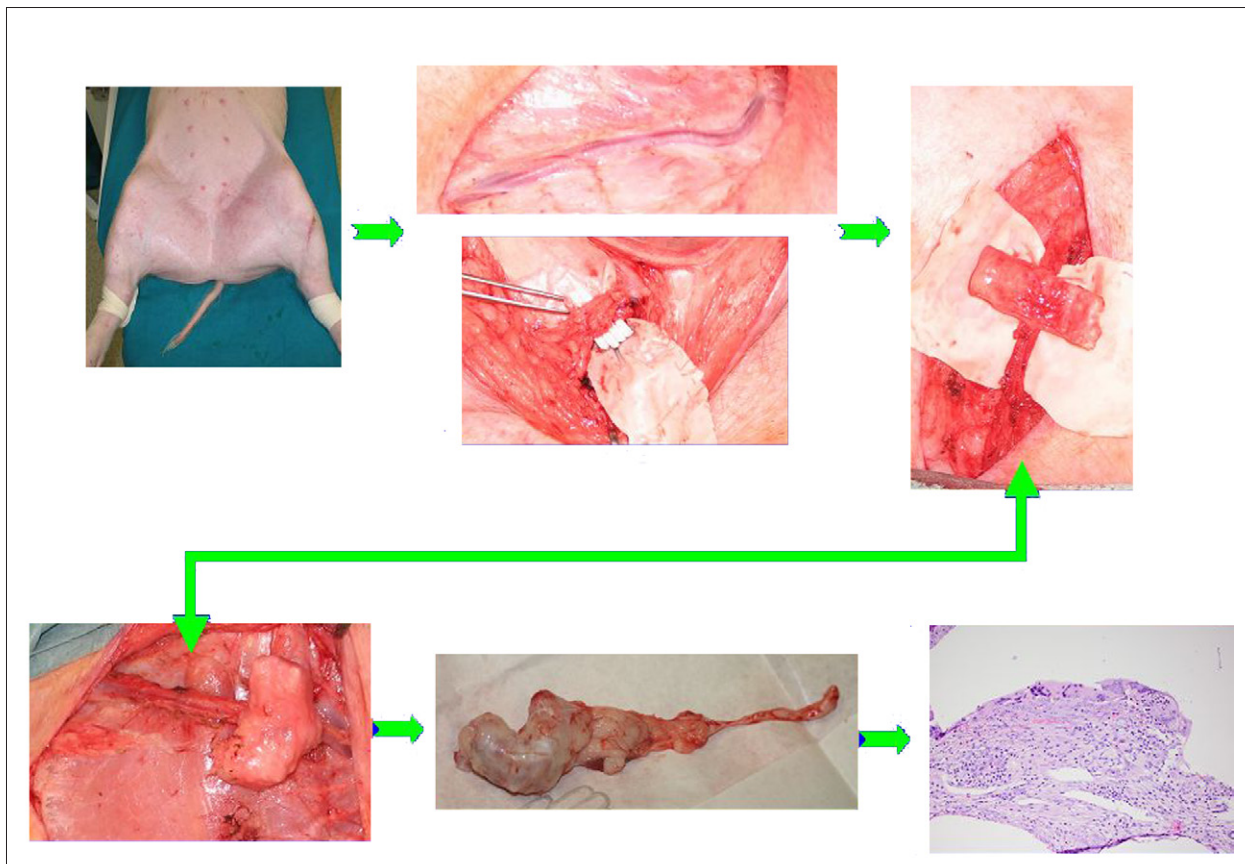


Figure 3. Our experimental study.

bundle, or musculovascular pedicle. Based on the same concept, Morrison et al prefabricated a thin axial-pattern skin flap in a rabbit model by implanting the femoral artery and vein

directly into subdermal layers of skin. This research suggested that vascular implantation provokes an extensive outgrowth of new vessels from the implanted artery and vein, and that

a neovascularization process begins within a few days of implantation and progresses rapidly by 8 to 12 weeks [12,13].

Without doubt, the ideal approach in reconstruction of the 3-dimensional structures of the face is the use of autogenous tissue. For this purpose, while providing inner lining with different tissues, a framework was usually formed by cartilage and bone to support these tissues. However, the difficulty of shaping autogenous tissues, the limited amount of donor-site tissues, and donor-site morbidity limit their use as a framework. For this reason, the use of alloplastic materials that can be shaped in detail 3-dimensionally and that are safer because they do not show resorption or deformation is becoming more popular. Porous materials, like polytetrafluoroethylene, are invaded by a fibrovascular tissue and become a single unit with vascular bed and tissues after they are implanted [14,15]. This situation makes them resistant to infection and movement. Because the instability and infection that are the most important risk factors for implant exposition are decreased, these materials are safer than nonporous ones. For reconstruction of 3-dimensional defects, in particular on the face, the most popular alloplastic material is high-density porous

polyethylene. This is obvious because of the increased number of experimental and clinical studies published. The most important factors that reduce the long-term biocompatibility of alloplastic materials are the presence of a chronic inflammation and the instability of the implant. Even a subacute inflammation may cause detachment of the fibrovascular capsule from the implant surface and therefore trigger the chain of events that results in implant exposure and extrusion.

Prefabricated flaps are a useful tool for the reconstructive surgeon because of specific preferred tissue composite, regardless of their native vascular origin, can be transferred as free or pedicled flaps, donor-site morbidity is reduced, and the functional outcome for patients may be more satisfactory [16,17].

Conclusions

Based on the results of our study, we believe that the use of high-density porous polyethylene in flap prefabrication may be a good option for reconstruction of 3-dimensional defects, especially in patients with limited donor tissues.

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