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British Journal of Oral and Maxillofacial Surgery 54 (2016) 664–668

BRITISH Journal of Oral and Maxillofacial Surgery
www.bjoms.com

Use of human nail for reconstruction of the orbital floor: an experimental study in rabbits

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Accepted 31 March 2016
Available online 16 April 2016

Abstract

The orbital floor is the thinnest part of the orbital wall, and in 20% of all maxillofacial injuries it is fractured. Autografts, allografts, and alloplastic materials are used in reconstruction, but there is no consensus about which material is the most appropriate. Nail is a semirigid material that is easy to reshape and is not antigenic. Alloplastic materials, which are used in reconstructions of the orbital floor, have various complications and are expensive. Autografts have donor-site problems, high rates of resorption, and take a long time to do. We created bilateral 10 mm defects in the orbital floors in 18 New Zealand rabbits. We reconstructed the left orbital floors with double-ground human nail while the right orbital floors were left open as controls. The orbital floors were examined macroscopically and microscopically at 4, 8, and 12 weeks postoperatively, and there were no macroscopic signs of infection, inflammation, or extrusion. Forced duction tests showed that it was possible to induce movement of the eyeball for all 18 of the reconstructed sides throughout the observation period, and in 14 of the 18 rabbits on the control sides. Positive forced duction test shows us that orbital muscles are trapped in orbital floor defect and due to this movement of eyeball is restricted. Acute and chronic inflammation, fibrosis, vascularisation, and the presence of foreign body giant cells were evaluated microscopically. Acute inflammation and the presence of foreign body giant cells were recorded as mild, whereas fibrosis, chronic inflammation, and vascularisation were severe, as were epithelialisation on the maxillary sinus side of the nails, calcification, and progression of collagen. We found no signs of resorption of the nails.

Keywords: Orbital floor reconstruction; Human nail; Biomaterial; Experimental

Introduction

The prevalence of orbital damage in maxillofacial injuries is about 40%, and half of that results from damage to the orbital floor.[1,2] The most outstanding feature that distinguishes "blow out" fractures from other maxillofacial fractures is the way that they fragment like egg-shells, and there is a need for a suitable material to reconstruct the orbital floor. The ideal material should be thin, light, enduring, easily-shaped, and radio-opaque but not be prone to infection that could interfere with further investigations.[3] It should also not be carcinogenic and have no potential for transmission of disease.[4]

Autografts, allografts, and alloplastic materials are used to reconstruct the orbital floor, but there is no consensus on which material is the best.[5–9] The most important complications of alloplastic materials are infection, foreign body reaction, and exposure.[10–12] The biggest disadvantages of allografts are their potential for transmitting disease and their cost.[13] Several donor sites have been described for

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http://dx.doi.org/10.1016/j.bjoms.2016.03.031

autologous grafts, but the extended duration of operation, donor site morbidity, and resorption of the graft, has limited their use.[14–16]

Human nail is easily shaped, semirigid, and not antigenic.[17] There is also little possibility of donor site morbidity because a new human nail grows rapidly. Excision of a human nail is quick and easy, so it will not affect the duration of the operation. All these properties indicate the possibility of human nail being used to reconstruct the orbital floor. Human nails are convex and multi-layered, and made up of cornified dead cells, And the structure and chemical composition are similar to those of hair. The properties of human nails, such as memory of form (like cartilage), the fact that they contain no living cells, are easily obtainable with minimal morbidity, and do not prolong operating time, suggest that they could be harvested.[17]

Finger nails have already been used successfully in the repair of composite tissue defects.[18–20] A fibrous capsule develops around the nail, which is placed on the back of a rat or rabbit and causes a foreign body reaction.[21]

Alloplastic materials used for reconstruction of the orbital floor are expensive and autografts cause donor site morbidity and take much longer. We therefore suggest that the structure and properties of nails make them a viable alternative to other materials.[17,21]

We have assessed the macroscopic and histopathological results of reconstruction of defects of the orbital floor in rabbits with human nails.

Material and Methods

Eighteen adult albino New Zealand rabbits aged between 3–4 months, body weight 2.5–3.0 kg, were used for the experiment.

The study was approved by the Şişli Etfal Training and Research Hospital Ethics Committee for Animal Experiments. The rabbits were kept in standard cages at room temperature, with free access to drinking water and commercial food. They were anaesthetised with intramuscular injections of 2% xylazine 5 mg/kg and 10% ketamine chlorhydrate 2.5-mg/kg, and spontaneous ventilation was maintained. Two ventral surfaces of 18 human cadaver nails were then shaved with a burr, and the layer of dead keratinocytes was uncovered to remove the epithelial layer, which is covered with epithelium bilaterally and which has a layer of dead keratinocytes in the middle. Nails were kept for 15 minutes in 0.55% Cidex® OPA (Advanced Sterilization Products, Johnson & Johnson, Irvine, CA, USA) solution and washed with sterile 0.9% sodium chloride. At the end of the 12-week follow-up period the rabbits were killed with a lethal intravenous dose of sodium pentobarbital (100 mg/kg).

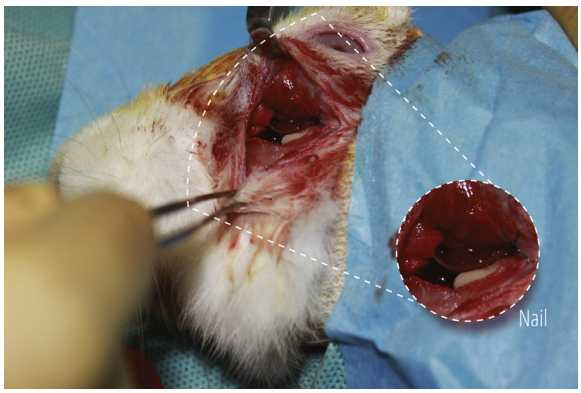

Fig. 1. Appearance of defect in the rabbit orbital floor reconstructed with 1 × 1 cm human nail.

Operative technique

An incision is made just above the two inferior orbital rims, and orbital defects 1 × 1 cm are made with an osteotome. The shaved and sterilised nails are cut to the correct sizes to cover the defects, put into the defects in the left orbit (Fig. 1), and fixed with 5/0 polypropylene sutures placed into the periosteum. The right orbital defects are left unreconstructed for macroscopic control. Skin incisions are closed primarily.

Macroscopic and histopathological evaluation

All rabbits were assessed macroscopically by the forced duction test. The groups were assessed histologically against specific criteria such as acute inflammation, chronic inflammation, fibrosis, the presence of foreign body giant cells, and vascularisation. For each criterion we used the modified histological scoring system described by Abramov et al. (Table 1).[21]

Table 1
Histological wound healing scores.

Variable	Score			
	0	1	2	3
Acute inflammation	None	Scant	Moderate	Abundant
Chronic inflammation	None	Scant	Moderate	Abundant
Amount of granulation tissue	None	Scant	Moderate	Abundant
Granulation tissue and mature fibroblasts	Immature	Mild maturation	Moderate maturation	Fully matured
Collagen deposition	None	Scant	Moderate	Abundant
Re-epithelialisation	None	Partial	Complete but immature or thin	Complete and mature
Neovascularisation	None	Up to five vessels/high power field (HPF)	6–10 vessels/HPF	More than 10 vessels/HPF