Reconstruction of Surgical Skull Defects with Hydroxylapatite Ceramic Buttons and Granules

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Summary

This paper is to report a new method of reconstructing surgical skull defects with hydroxylapatite ceramics. The latter consist of Ca_{10}(PO_4)_6(OH)_2, which has a biological affinity with mammalian bone minerals. The author has designed two cranioplastic materials using hydroxylapatite ceramics: apatite buttons for burr hole skull defects and apatite granules for linear skull defects. The bone defects during 100 cases of standard craniotomy were successfully reconstructed with these materials with satisfactory cosmetic results. Hydroxylapatite ceramics are characterized by the excellent biocompatibility and biostability with a resultant bony fusion.

Keywords: Hydroxylapatite ceramics; apatite buttons; apatite granules; burr holes.

Burr hole and linear skull defects during neurological operations are often reconstructed with autogenous bone chips or acrylic resins. However, these conventional materials have, respectively, such serious drawbacks as resorptions with resultant skin retraction or local inflammatory reactions with resultant fluid collection. Recently, ceramics are widely accepted as an excellent biomaterial for the bone tissues and have been used in dental, otological, orthopaedic and neurological fields. Among various kinds of ceramics available, hydroxylapatite ceramics comprising Ca_{10}(PO_4)_6(OH)_2 are known to have a biological affinity with mammalian bone minerals. Accordingly, they are extremely biocompatible and biostable with resultant bony fusion between the implants and the host bone. In this paper, the author presents a new method of reconstructing surgical skull defects, using newly designed apatite buttons and granules made of hydroxylapatite ceramics.

* Apeceram manufactured by PENTAX company: Asahi Kohgaku K. K., Tokyo, Japan.

Materials and Methods

The author has designed two cranioplastic materials: apatite buttons for burr hole skull defects and apatite granules for linear skull defects. Both materials were synthesized from hydroxylapatite [Ca_{10}(PO_4)_6(OH)_2] powder and were fired into dense ceramics at about 1100°C. Hydroxylapatite ceramics were characterized by the Ca/P ratio of 1.67 which was quite similar to the content of mammalian bone minerals. Apatite buttons were designed so as to adjust burr hole skull defects measuring 15 mm in diameter. A dome-shaped cap measuring 15 mm in diameter, 2 mm in the central thickness and 1 mm in the peripheral thickness, was attached by a cylindrical protrusion measuring 8 mm in diameter and 3 or 5 mm in height (Fig. 1). Apatite granules were designed for both burr hole and linear bone defects. The granules were irregular in shape, measuring 600-1,000 μm in diameter. Apatite buttons and granules were sterilized by autoclaving for 30 minutes and steeped in water with Gentamycin before use. Apatite granules were usually mixed with the same amount of autogenous bone chips which were collected from the...
Fig. 2. Apatite granules are usually mixed with the same amount of autogenous bone chips which were collected from the craniectomy sites (Fig. 2). At closing the skull, three methods were available: burr hole skull defects were reconstructed by apatite buttons with (1) or without (2) a reconstruction of linear skull defects by apatite granules, or (3) all of the bone defects were reconstructed by a mixture of apatite granules and autogenous bone chips. The cases in the present series were followed over a period of up to 2 years by both clinical examination and roentgenograms.

Clinical Results and Illustrative Cases

Cranioplasty with apatite buttons and granules was performed in 100 cases which underwent standard craniotomy. Three to eight apatite buttons and/or 5–10 g of apatite granules were usually necessary for each operation. The time required for the operative procedure was usually within five minutes. Wound healing was uneventful and there were no signs of inflammation or extrusion of the implants. Neither adverse reactions nor resorption of the implants were observed within a period of up to 2 years. As there were no visible skin retractions, both the patients and the doctors could hardly detect the skull defects following the craniotomy. The postoperative course was satisfactory in all patients except for one who showed scattering of apatite granules into the operative field because of an incomplete suture of dura mater. However, this patient showed an uneventful postoperative course, requiring no further operations as long as 18 months. The surgical procedures and results in the representative two cases are illustrated in Figs. 3–10.

Case 1: This 45-year-old woman was operated on for a frontal falx meningioma. A bifrontal craniotomy was performed with 8 burr holes. After the tumour had been removed, the skull defect was reconstructed with both 8 apatite buttons and a mixture of apatite granules and autogenous bone chips (Fig. 3). A postoperative roentgenogram showed apatite buttons and granules in acceptable positions (Fig. 4). An X ray tomography showed that each apatite button perfectly fitted the burr hole (Fig. 5). One could detect neither skin retractions nor burr hole sites in the forehead (Fig. 6).

Case 2: This 65-year-old woman was operated on for a metastatic brain tumour in the right frontal lobe. A right frontal craniotomy was performed and the skull defect was reconstructed by a mixture of apatite granules and autogenous bone chips. The postoperative course was uneventful and clinical inspection showed no skin retraction (Fig. 7). However, six months later, the patient developed...