

The Use of Particulate Hydroxyapatite and Plaster of Paris in Aesthetic and Reconstructive Surgery

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Abstract. The authors describe their early investigative results of using a mixture of hydroxyapatite (HA) and plaster of Paris (PP) in skull and frontal sinus defects in a large series of cats. Histologically, bone was found to form and infiltrate the HA-PP implant over a period of months, with gradual resorption of the plaster in 6-8 weeks. Clinically, the HA-PP combination has been used in 24 patients over the past seven years for various skull, zygomatic, and mandibular defects.

Key words: Hydroxyapatite—Plaster of Paris—Synthetic bone substitute

The search for a suitable material to replace autogenous bone for certain reconstructive and aesthetic procedures has led us to consider the use of hydroxyapatite (HA). This material is a suitable substitute since it exhibits the strength characteristic of bone, an ability to mimic bone, ingrowth of fibroblasts and osteocytes [17], and finally bone formation. Many authors [2, 4, 9-13, 18-21, 23, 24, 27-29, 31] have described the use of HA.

HA in block form must be contoured exactly to fill the defect. The particulate form of HA was considered to be more desirable for applications in the facial skeleton. However, the particles migrate if no filler, e.g., blood or serum, is used. In order to limit particle migration and provide stability during the period of bony ingrowth, one of us (J.H.) suggested combining HA with plaster of Paris (PP). Plaster of

Paris has been used to fill bony defects for almost 100 years. It was first used in the Trendelenburg Clinic in Bonn by Dreesman in 1892 [8]. Extensive clinical and investigative work has confirmed that PP is safe and gradually resorbed over a few weeks.

Following our early clinical success using the HA-PP combination for bilateral mandibular contouring, an experimental laboratory investigation was conducted jointly with our neurosurgical colleagues [17]. Cats were chosen for the experiment because of the presence of frontal sinuses in a reasonably sized animal. There were two groups of 30 cats each. Following suitable anesthesia, hair shaving, and skin preparation, the periosteum over the left frontal sinus was removed. A trephine hole, 1.2 cm in diameter, was placed in the right parietal region, the left frontal sinus was unroofed, and the mucosa was removed. The defects in one group were filled with a mixture of 3 g of 18-40-mesh dense sintered ceramic hydroxylapatite [Alveograf brand of durapatite (supplied by Sterling-Winthrop Research Institute, Rensselaer, NY)], 1.5 g of medical-grade calcium sulfate hemihydrate (plaster of Paris) (supplied by USG Corp., Chicago, IL) containing 0.85% K_2SO_4 , and 0.5 mL of sterile water. The defects of the second group were filled with a mixture of 3 g of porous hydroxylapatite particles with a particle diameter of about 425-1000 μm and a pore diameter of approximately 200 μm [Interpore 200* biomatrix granules (Interpore International, Irvine, CA)]; 1.5 g of plaster of Paris powder with 0.85% K_2SO_4 , and 1.2 mL of sterile water. These compounds were easily mixed and readily molded to fill the defects created.

The cats in both groups were sacrificed at regular intervals over a 12-month period. At the time of sacrifice the implanted defects in the skull were well

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Fig. 1(A,B) A 50-year-old patient is shown with a frontal and right temporal defect postresection of sphenoid bone. **(C,D)** Intraoperative photos show temporal and frontal defects prior to and after hydroxyapatite-plaster filling of defects. **(E,F)** One year postoperative appearance following reconstruction of frontal and temporal defects. **(G,H)** X rays showing one year before and after HA-PP filling of frontal defect

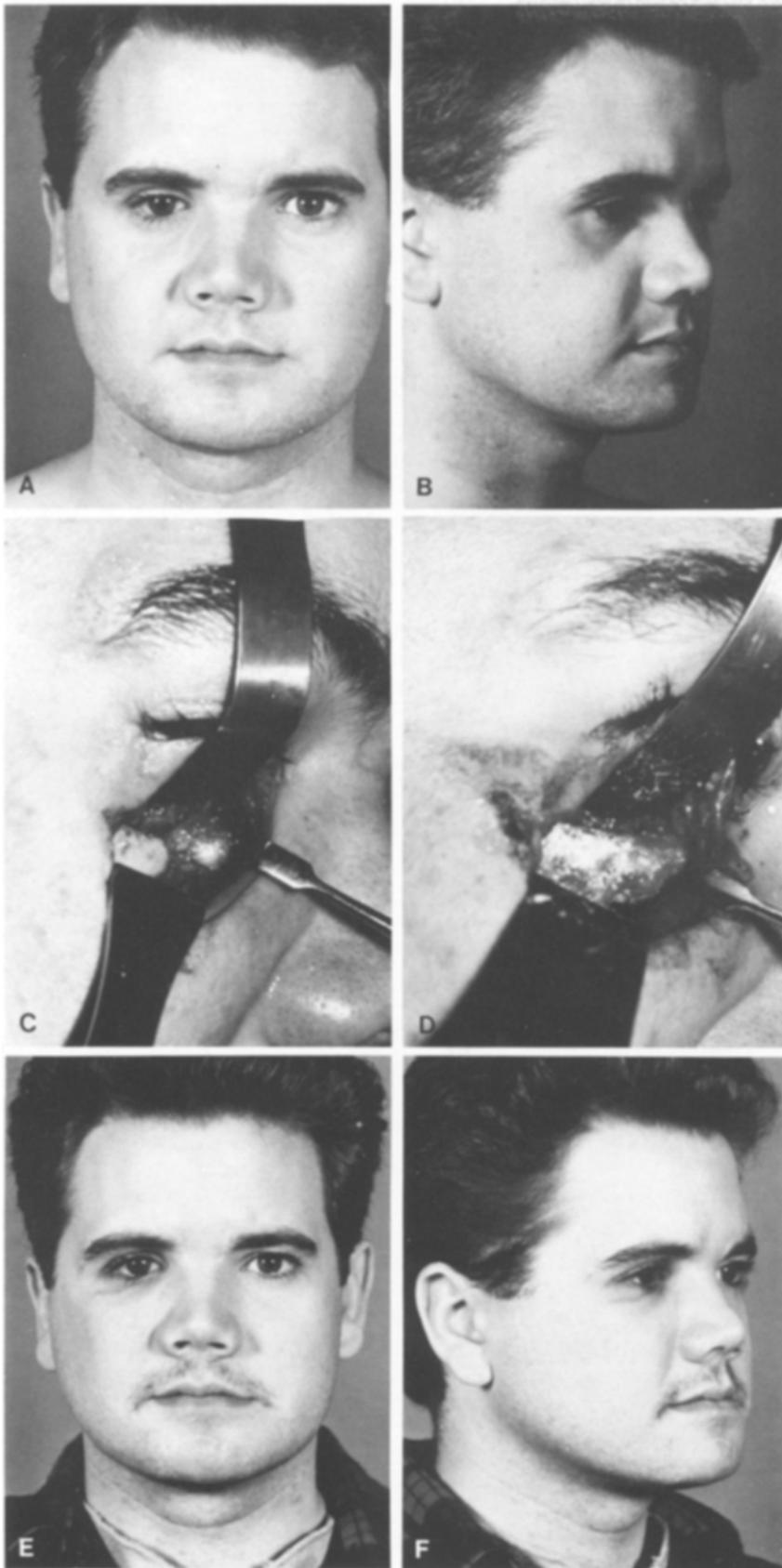


Fig. 2(A,B) Preoperative appearance of a 28-year-old with depressed fracture of the right zygoma sustained six months previously. **(C)** Intraoperative photos showing depressed zygomatic ridge. **(D)** The defect is shown reconstructed with HA-PP. **(E,F)** Six months following reconstruction of the right zygoma

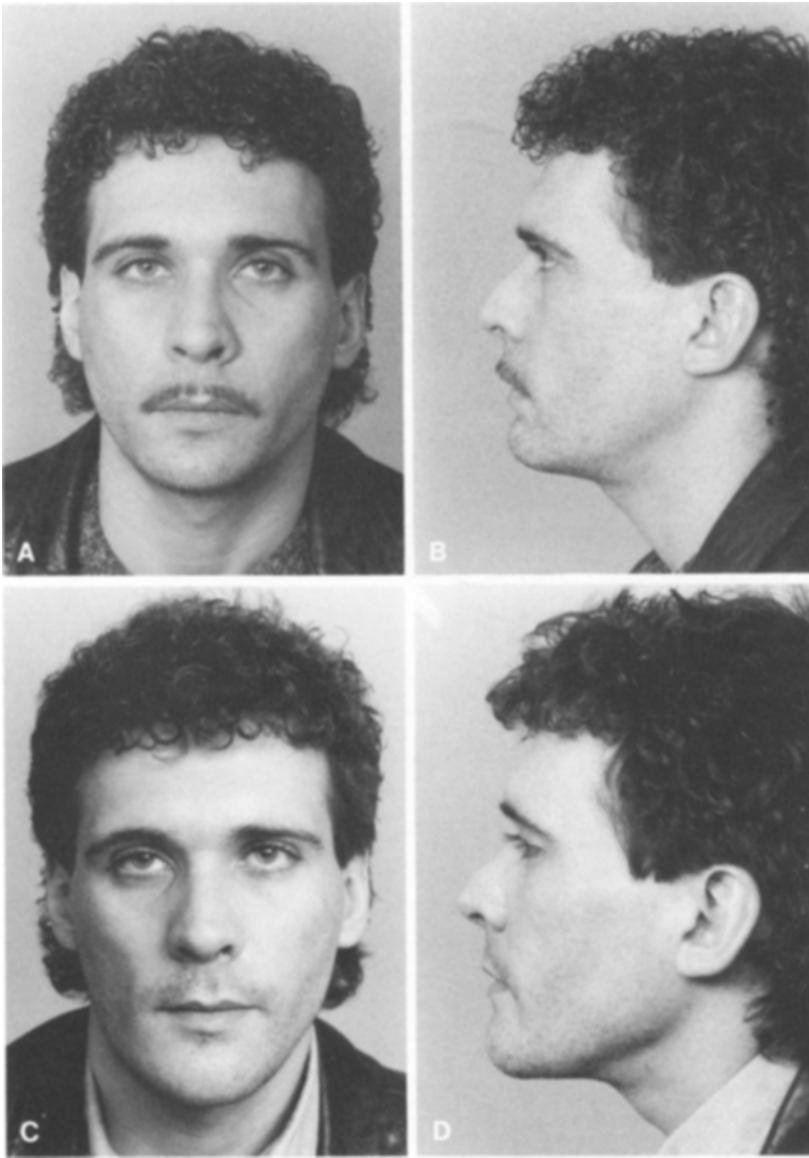


Fig. 3(A,B) Preoperative photos of a 28-year-old male with micrognathia. **(C,D)** One month postaugmentation of the chin with HA-PP

healed. There was no evidence of reaction, infection, or displacement of the implanted material and the cosmetic effect was excellent. New bone growth was evident in the defects. There was more extensive bone formation in the group of cats that received the porous HA-PP compound. Histological examination of 40-mm-thick sections with a Merz-Schenk reticle at 160X magnification with a Leitz Dialux microscope was performed.

From these studies we found that as early as one month there was evidence of a large number of osteoblasts and osteoid material around the porous particles in addition to fibrous material. After three months there was a decrease in the fibrous material

and a moderate amount of new bone was present. This bone formation continued during the entire 12-month period by which time there was approximately 70% bone and 30% fibrous tissue. There was no evidence of acute or chronic inflammation.

Clinical Studies

Methods

The material used to fill the defects was Interpore 200 in the particulate form combined with PP. Interpore 200 is made by converting the calcium car-

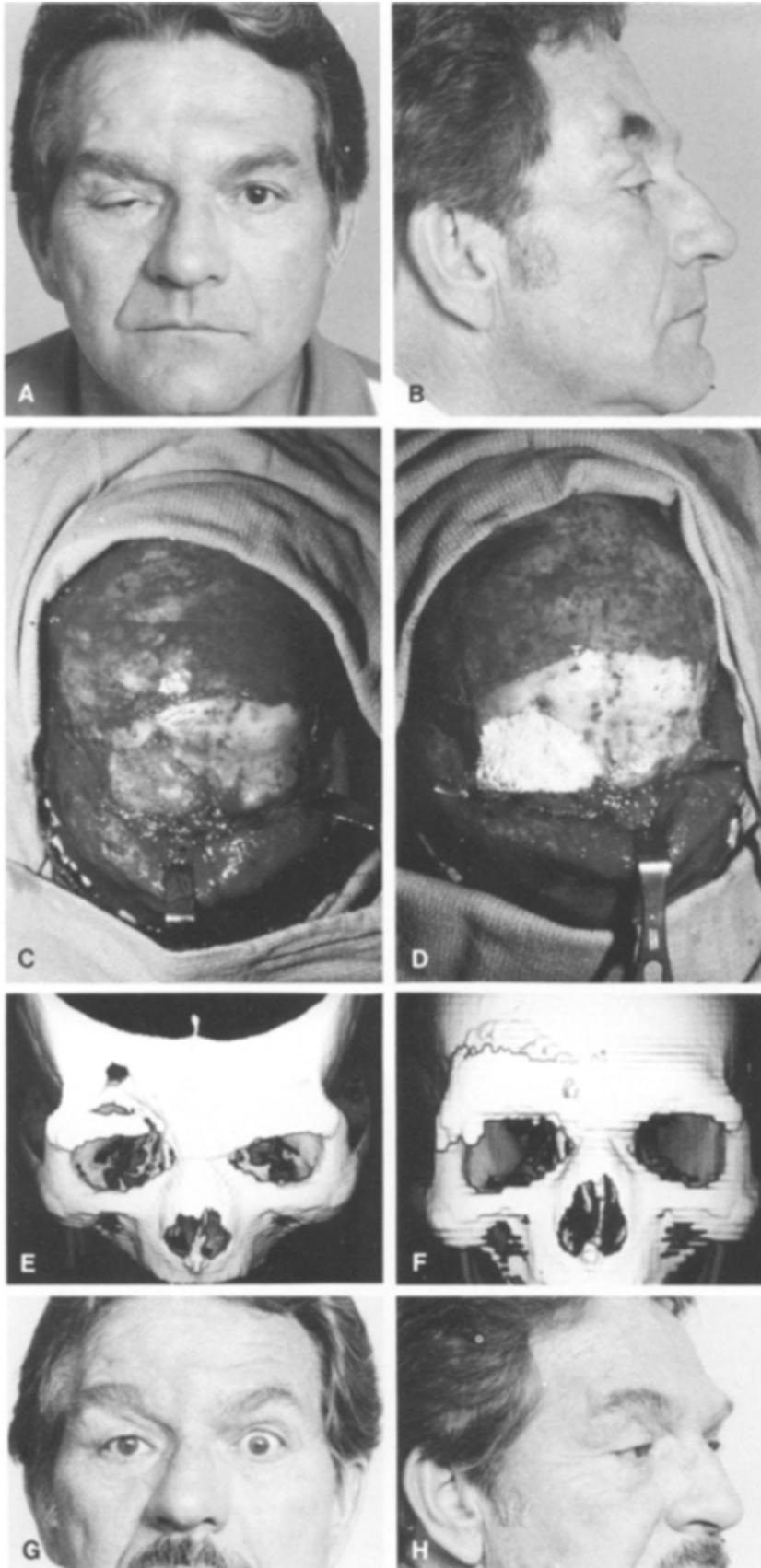


Fig. 4(A,B) A 50-year-old patient is seen with a marked post-traumatic deformity of right frontal orbital region. **(C)** Intraoperative photos show the large frontal defect. **(D)** The defect is shown in its newly constructed contour utilizing HA-PP. **(E,F)** Pre- and postoperative radiographs showing frontal defect and postreconstruction. **(G,H)** One year following reconstruction



Fig. 5(A,B) This 22-year-old patient is shown with micrognathia and hypoplasia of mandible. **(C)** Multiple HA-PP inserts were used as shown in this intraoral view. **(D,E)** Seven years after having had multiple intraoral HA-PP implants. **(F)** Radiographs are shown over a three-year period showing gradual building of mandibular defects

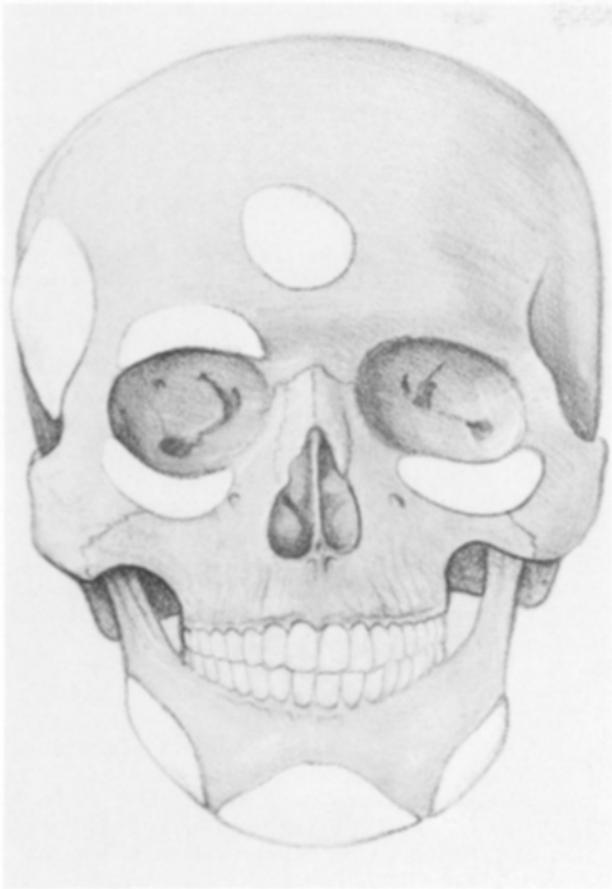


Fig. 6. The multiple sites of the craniofacial areas that have been reconstructed with HA-PP are illustrated

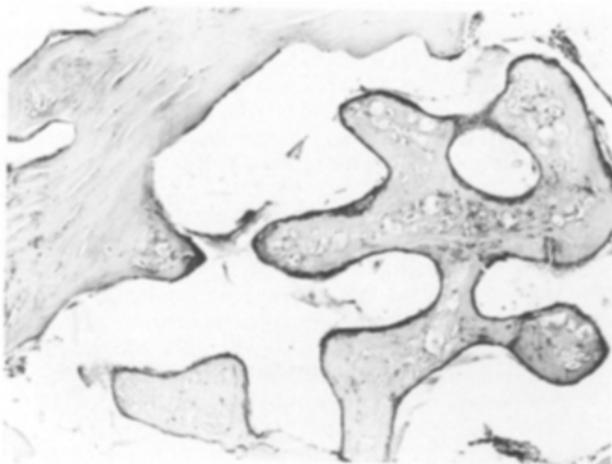


Fig. 7. A left temporal bone biopsy from a previous HA-PP augmentation at 9 months; 100 \times photomicrograph demonstrating mature trabecular bone

bonate exoskeleton of the marine coral *Poritidae* porites to HA with a nominal pore size of 200 μm by a hydrothermal exchange reaction [20, 26]. Plaster of

Paris is produced by heating gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) so that it loses 75% of its water and becomes a hemihydrate of calcium sulfate. It is easily sterilized by dry heat at 120°C for 4 h. Both clinical and investigational use of PP as a substitute for bone has been reported previously [1, 3, 5, 14–16, 22].

In our series the HA and PP are combined in the approximate ratio of 2 : 1 or 1 : 1. Prior to mixing the HA particles and PP, sterilization was carried out using dry heat at 120°C for 4 h. The relative amounts used were 3.5 g of HA particles, 1.5 g of medical grade USG PP powder, and 0.5–1.2 mL of distilled water depending upon the pliability desired. The HA-PP compound was mixed rapidly within 3–5 min, applied with a spatula or a 5-mL syringe, and was suitably contoured. The operative areas were closed in layers as were the oral defects. Antibiotics (first-generation cephalosporins) were given at the time of surgery and for 96 h postoperatively.

Results

A total of 24 patients over a period of seven years have had aesthetic and reconstructive procedures carried out in the skull and facial area. Traumatic and surgical defects of the skull, frontal bones, zygoma, nose, and mandibular defects were reconstructed. The surgical results are shown in Figures 1–6. Use of the HA-PP implants resulted in an improved aesthetic appearance.

Advantages

The combination of HA-PP and water creates a pliable mass that is moldable for approximately 3–5 min which allows for excellent contouring to fill the defects. The PP prevents the migration of the particulate HA from the implant site. The gradual resorption of the PP over a period of weeks or months coincides with the ingrowth of fibroblasts and osteoblastic activity resulting in the formation of new bone (Fig. 7). Minimal resorption of the HA-PP compound occurs (1–2%); this is replaced by new bone formation. There is a very low incidence of infection or inflammatory reaction.

Disadvantages

Five patients were noted to have serous effusion. Therefore, closed suction drainage of the operative area is used for 48–72 hours. One patient had to have a portion of the implant removed because of persistent drainage and partial exposure. Insufficient augmentation of the defect occurred in our earlier patients but this has been rectified with experience.

Comments

The use of HA-PP, which is osteoconductive when placed next to bone, appears to be most practical in nonstress-bearing areas such as described in our series. The bone morphogenetic osteoinductive protein (BMP-2), as described recently [6, 24, 25, 31], should be considered for incorporation with the HA-PP plaster to form a biomaterial that would yield the most rapid bone formation, particularly in stress-bearing areas.

Summary

The combination of HA and PP offers a suitable substitute for reconstructing craniofacial defects. The desirable features include the ability to readily contour the material to all defects, biocompatibility with negligible resorption, and ease of sterilization. The material is useful for both aesthetic as well as major reconstructive procedures of the bony areas of the face.

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