

Waste Material to Biomaterial Egg Shell as A Bone Graft Substitute— A Clinical Study

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Introduction

Since early times research has been conducted to find out suitable graft materials that can repair bony defects of the human musculoskeletal system. The ideal bone graft should be biocompatible, osteoinductive or osteoconductive, easy to use and inexpensive. There is no doubt that auto grafts are the most preferred biomaterial but it has some limitations also; such as, limited supply, need for second surgery, donor site morbidity etc. Hydroxyapatite, $Ca_{10}(PO_4)_6(OH)_2$ a hexagonal structure with bioactive, biocompatible and osteoconductive properties that are chemically and crystallography similar to bone; has received a great deal of attention for use as a bone graft substitute. It is reported that yearly, 1, 90,000 tonnes of egg shell is generated in India. In our study we

synthesized hydroxyapatite from eggshell and used it as a bone substitute in the field of maxillofacial surgery. Significant bone regeneration was observed and density remained steady post operatively indicating complete bone healing. The promising result concluded that eggshell derived hydroxyapatite is a versatile novel bone graft which is efficient, cost effective and easily available biomaterial, which can be sterilized conveniently.

Keyword: Bone Graft(S), Bone Regeneration, Hydroxyapatite, Osteoblast, Osteoclast.

Introduction

For centuries research has been conducted to find out suitable graft materials that repair bony defects of the human musculoskeletal system. Since the first successful bone transplantation carried out in 1668 by Van Meek'ren

a Dutch surgeon, more than 50 bone substitutes have been described in the literature (Kathagen, 1986, Mainard et al., 1990). [1] Unfortunately none has fulfilled all the requirements to gain wide acceptance in clinical practice. [1] The ideal bone graft should be biocompatible, osteoinductive, osteoconductive, easy to use and sterilize and also inexpensive. Although a number of different materials have been tested since then, the benchmark remains autogenous bone, with common donor sites being the ilium, rib, fibula, or tibia. [2] It is more biocompatible and has greater osteogenic capacity than any other graft. The disadvantages of autografts are it requires secondary surgery, more operation time, more intraoperative blood loss, donor site morbidity, limited graft supply etc. Hydroxyapatite, $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$ a hexagonal structure containing 70% inorganic (apatite calcium phosphate) and 30% (mostly collagen) organic material by weight and Ca/P ratio is 1.67. The synthetic form of hydroxyapatite has been shown chemically and crystallography similar to bone with absence of antigen response, biocompatibility and lack of significant resorption. Thus it has received a great deal of attention for use as a bone graft substitute. Egg shell contains about 91% of CaCO_3 (Rivera et al 1990; Nakano et al 2003). It is reported that 1,90,000 tonnes of waste egg shell is generated in India, and might be used as a calcium source in human nutrition (Schaafsma et al 2000). [3] In our study we synthesized hydroxyapatite from egg shell and used it as a bone substitute in the field of maxillofacial surgery. The aim of this study was to evaluate the efficacy of egg shell derived hydroxyapatite in the bone regeneration of mandibular and maxillary defects, secondary to surgical removal of unerupted mandibular third molar and cystic removal/apicectomy of maxillary anterior teeth respectively.

Materials And Methods

Egg shells were washed thoroughly, initially in tap water and later in distilled water. The adhering membrane was separated manually and shells were dried at room temperature. The shells were crushed in a porcelain mortar and pestle and incinerated at 300 degree centigrade and ashed at 750 degree centigrade for about 5 hours. This procedure decomposes the organic component. Then by granulometry, egg shell fine powder with a mean diameter ranging from 400 micrometer to 600 micrometer was made. The ultra grain particles were stored in polythene covers and sterilized at room temperature with ethylene oxide for 6 hrs.

In vitro cytotoxicity test was performed by direct contact method and approved by institutional ethical committee.

In August 2019, egg shell hydroxyapatite graft material, was used on two patients, in Department of Oral & Maxillofacial Surgery, K.D. Dental College and Hospital.

A 18 year old female patient, who reported for extraction of partially formed unerupted mandibular third molar that had not breached overlying hard and soft tissue. The lateral trepanation technique of Bowdler Henry was performed under local anesthesia. Prepared egg shell graft was mixed with patients' blood (3ml blood was drawn from patients' anterior cubital fossa) and placed in the surgical site.

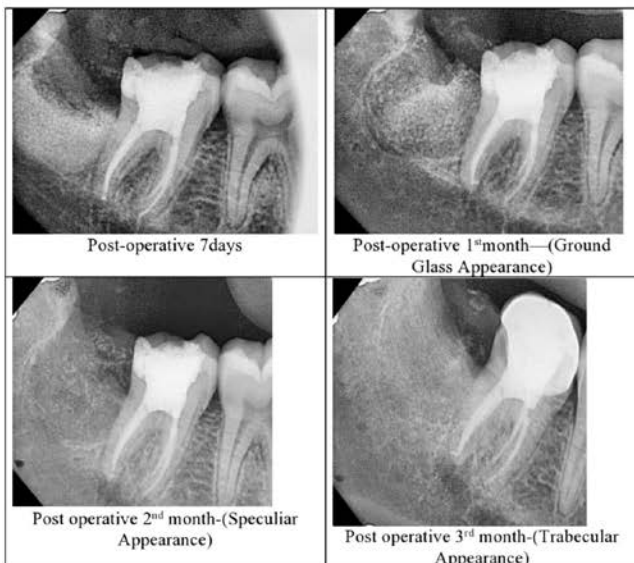
A 32 year male patient treated for radicular cyst; apicoectomy was performed under local anesthesia, and prepared egg shell graft was mixed with patients' blood (3ml blood was drawn from patients' anterior cubital fossa) and placed in the defect.

Result

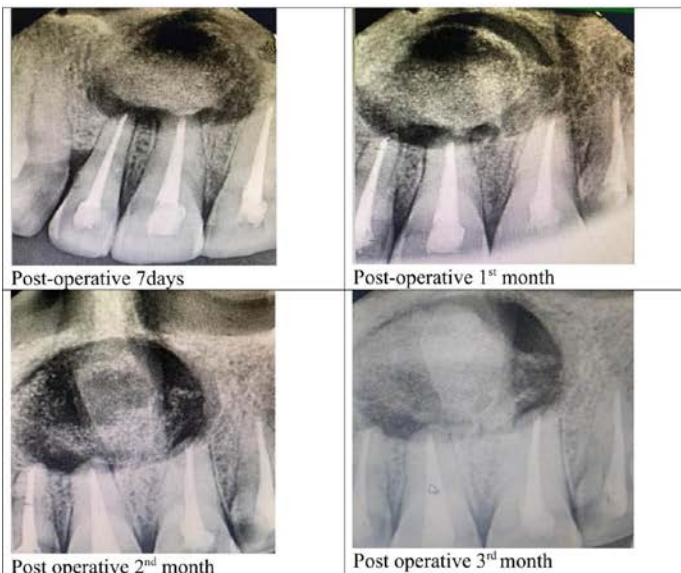
Clinically the wound healed uneventfully in both the cases. No post operative complication was noted. Patients were recalled after 7 days, 1st month, 2nd month and 3rd

month and bone healing was measured radiographically at the following time.

Radiographic Interpretation of case 1

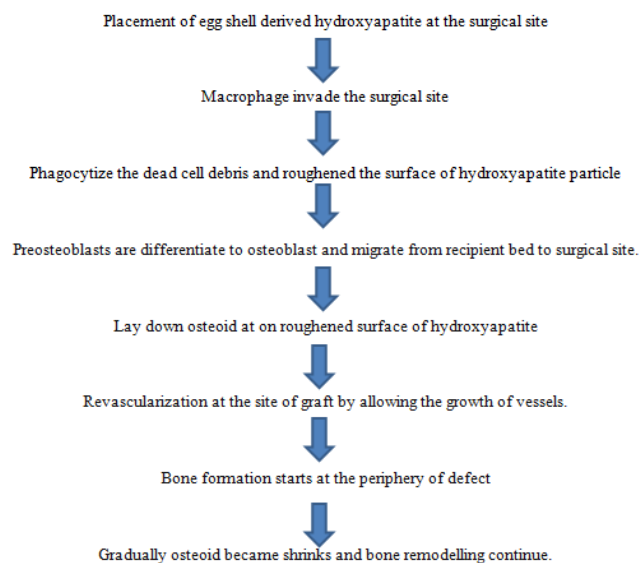


Radiographic interpretation of Case 2—



Discussion

Egg shell derived hydroxyapatite showed good biocompatibility; no local or systemic toxicity, no inflammation and no foreign body response.[2] Hydroxyapatite has well known osteoconductive property that allow ingrowth of vessels and osteoprogenitor from recipient bed to graft site. Mechanism of the graft are described below.



Another significant property of hydroxyapatite is slow rate of resorption, followed by less chance of stress concentration that lead to lack of possibility of bone fracture.

Conclusion

Egg shell is a natural source for synthesis of hydroxyapatite which not only has excellent biocompatibility but is also inexpensive . The agricultural waste management will have to play an important role in the production of biomaterials from garbage materials. Considering the result, we conclude that egg shell is versatile novel bone graft that provide an effective alternative to traditional allogenic graft in the field of maxillofacial surgery. Further studies with large sample group should be taken up to expanding the topic.

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intellectual content, gave final approval and agree to be accountable for all aspects of the work in ensuring that questions relating to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Ethics Statement/Confirmation Of Patient's Permission

The study has been approved by the ethics review board of the institution. Written informed consent was obtained from patients.

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