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Ecografts – Contemporary Biologically Derived Bone Grafts - A Review

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Abstract:- In recent times, in order to replace missing teeth in partially edentulous and completely edentulous patients, the implant-supported prosthesis is considered as the most preferred treatment modality to restore normal function and esthetics in routine dental practice. To achieve optimum esthetics and successful osseointegration for implant-supported prosthesis adequate bone quantity and quality are required but osseous ridge deficiencies are more often the norm than the exception following tooth loss, trauma, infection, periodontal disease.

Most successful bone substitutes in today's date are autografts or allografts which are also associated with the complications of bone harvesting which include infection, pain, blood loss, therefore there has been a significant interest in forage of alternative bone substitutes.

Ecografts are organic structures, for example, corals, marine sponges, wood, and vegetal items that can be utilized as conciliatory formats to create permeable bioceramics that guzzle the regular morphology and multiscale permeable association. They have one of a kind building structures and synthetic sythesis for the repair and recovery of bone tissue.

This review gives an image of bioinspired ceramic production for medicinal applications and features the innovative and mechanical difficulties related with this intriguing and entrancing field of research.

I. INTRODUCTION

Generally missing teeth in the partially edentulous and completely edentulous patient is replaced with a fixed partial prosthesis, complete denture prosthesis, removable partial prosthesis, and implant-supported prosthesis. Currently, the implant-supported prosthesis is considered favorable treatment essential to restore normal function and esthetics in routine dental practice. To achieve optimum esthetics and successful osseointegration for implant-supported prosthesis adequate bone quantity and quality are required but often these patients have ridge deficiencies following toothloss, trauma, infection, and periodontal disease.

Until today numerous different materials are found to pack the bone damages. These may be autografts, allogenic, xenogenicbone materials which are used. 1 The most assuring bone replacement procedures are the autografts in which bone from an individuals body from point mostly being the iliac crest, distal femur or the proximal tibia has its own collateral damage associated with it that is pain, infection, loss of blood, scarring, donor site morbidity there has been a forage of interest in searching for alternatives in natural bone substitutes for bone regeneration.1 Vast knowledge of bone repair and regeneration is vital for the new materials for the therapy of bone diseases and other defects.

In tissue engineering, allografts that are void of the osteogenic, osteoconductive or osteoinductive potential are being refined in order to imitate the bone microenvironment by the addition of bone progenitor cells and other growth factors. So, novel biomaterials and scaffolds are required more than ever to ideally and effectively substitute infirm tissues, activate the body's own regenerative mechanism, furthermore to enhance tissue healing.

Porous structure and progressively orchestrated morphology of bone is as yet an inquiry given its restrictions in the assembling advances. In the attempt to bridge this gap, materials scientists are in forage of fascinating properties of natural layouts as ecografts as new origins of inspiration to achieve innovative bio templated devices.

From a biomaterials perspective, marine structures have an expansive quality of these characteristics for tissue engineering. Marine skeletons are impeccable bioresources that have customized architectures that give them structural brace, and other roles operable for tissue repair and regeneration.

Seashells, sea urchins which are marine structures with dense lamellar structures, cuttlebone, and coral with interconnected pores are abundant of bioactive elements and therefore classify as important medical materials potentially and functionally used for tissue engineering and for drugdelivery. (2,3)

Natural materials, ecografts possess predominant biological and functional structure as in comparison to synthetic materials as the origin of new biomedical applications. Therefore, to make most of what is given to us in such abundance, scientists are seeking the fascinating characteristics of natural structures biologically derived ecografts as sources of development to secure innovative biotemplated devices and as alternates to conventional bone grafts.

II. CLASSIFICATION

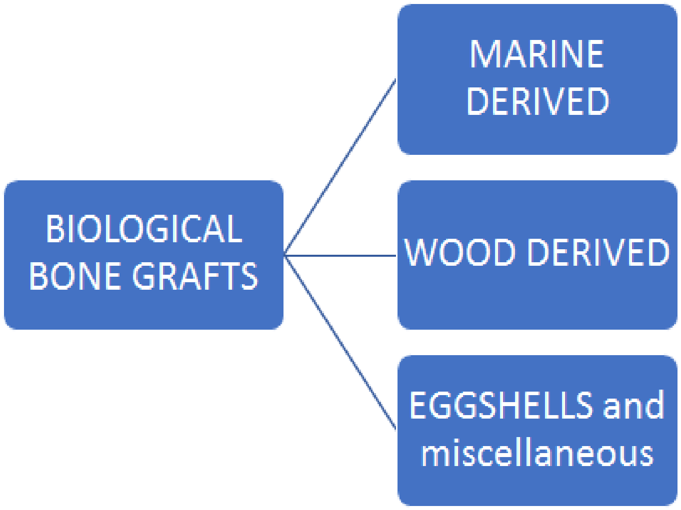

Fig 1

III. MARINE DERIVED SKELETONS

White et al. developed the alleged "replamineform process" to duplicate the porous microstructure of natural CaCO3-based corals that are not possible to make unnaturally.(4) Marine skeletons contain trace components of Sr, Mg and sodium and encompasses a distinctive design, with wonderful medical specialty, strength and resilient properties and considerable success as mineral precursors and bone graft materials. There's placing proof of the osteointegrative properties of these materials in vivo into a medically acceptable bone form. (5,6) This has spurred on researchers to conduct future studies during which marine skeletons are regenerate into calcium phosphates and encompassed into the structure of biomaterials to induce bone formation. (7, 8 – 11)

A. CORALS

The most encouraging corals that have a bone-like morphology are Porites (all-out porosity beneath 60 vol%, poresize run inside 140–160 lm, every one of the pores interconnected), Goniopora (all out porosity over 70 vol%, large pore size going from 200 - 1000 lm).(22)The machined coral shape is thermally treated at 900°C so that every natural substance is evacuated and CaCO3 is decayed, framing CaO while keeping up the porous microstructure of the first coral.

Coral-inferred hydroxyapatite is monetarily accessible to specialists as permeable granules for filling innate or precisely initiated (e.g., the expulsion of bone tumor) defects, permeable squares for bone expansion (ProOsteon),(23) spinal combination, periodontal surgery, porous plates for orbital floor fix.

Financially, the utilization of coral came into utilization in the mid-1990s, getting to be accessible as Biocoral and Interpore. (24) In a creature contemplate a three-dimensional coral skeleton structure displayed hard tissue growth as it is resorbed and totally supplanted by new bone. Comparable outcomes were seen when the coral skeleton was utilized in human implantation. (25)

Albeit coral fundamentally takes after trabecular bone, its mechanical properties are too weak for load-bearing applications. (26) This impediment can be tended to by hydrothermally changing over coral skeletons to calcium phosphate-inferred coralline, in which the coral structure is held, followed by sol-gel covering to improve quality for load-bearing skeletal applications. All in all, coralline hydroxyapatite is related to two significant impediments. There are a few burdens that are looked for what it's worth for each new thought. The main issue is environmental because of the collecting of regular corals and conceivable harm to marine biological systems, and the subsequent issue is related to the mind-boggling expense contrasted with different choices accessible for a similar application.

➢ *Coral Skeletons and its Dental Applications*

Corals are one of the normal materials prescribed to have potential in dental hard tissue restoration. A couple of other marine skeletons, for instance, marine sponges, seashells, and foraminifera have moreover been concentrated for dentistry applications. Coralline has been known as the identical representation of alveolar tissue and can be utilized for recovery of jawbone, dentine or periodontium. (27)

➢ *Marine Sponges*

Marine sponges are astoundingly appealing trailblazers for the production of bioceramic structures on account of their 3 Dimensional profoundly interconnected penetrable building which is the delayed consequence of a millenarian headway for water filtration..

Marine sponges share much just the same as multi-cell tissues. Similarities, from a biochemical and morphological perspective, exist between a marine sponge and vertebrate extracellular cross section prescribing that the key standards of affiliation developed initially by marine sponges.

Marine sponges having a place with the group of "Elephantear" were likewise as of late utilized by Boccardi et al. to make 45S5 Bioglass-inferred glass-ceramic scaffolds; commercial 45-PPI polyurethane froths were additionally utilized to produce reference tests under a similar handling conditions for near purposes.(28) Advantages of natural marine formats incorporate the likelihood of accomplishing superior mechanical properties contrasted with platforms made by poly-urethane foam replication (up to 4 MPa versus 0.05 MPa in compression) because of a diminishing in porosity (68–7(vol% vs85–90 vol%) without influencing the pore interconnectivity (higher than 99% in the two cases).

Until this point in time, three sorts of collagen are distinguished within marine sponges. All sponges are made of collagen fibrils 22 nm slight with profoundly arranged intermittent banding. This collagen fibrils are emitted in packs likewise to vertebrates. (29) The amino corrosive arrangement and genome organization are comparative despite the fact that the ultrastructure of collagen is moderately basic thought about to vertebrate collagens Correspondingly, collagen fibrils are eagerly associated with proteoglycans, which, in mammalian tissue design, shape and structure at the long-expand scale. Dermapotin, fibronectin, and tenascin polypeptides are similarly found in marine sponge collagen fibers and cross-react with antibodies raised against vertebrate analogies underlining their ordinary beginning stages. Various sponge species have a simple of sort IV collagen found in vertebrate cellar film collagens. The association of collagen fibrils is comparable to collagen type XIII which sticks cells to surfaces. (28)

It has been demonstrated that the arrangement of tissue in vivo within a month is both broad and well developed, with the quality and structure of tissue being proportional to juvenile bone and neocartilage.

B. Cuttlebone

Cuttlebone being the cuttlefish, inner shell, with an extraordinary structure that gives a close impartial lightness impact for cuttlefish at different jumping profundities. Cuttlebone shows high compressive quality, for it must withstand hydrostatic pressure at profundity and be as weightless as conceivable to expand lightness. It has a pore size range from 200 to 600 m and porosity of above 90%,(29) with indistinguishable science and crystallography as coral. The coordinated effort of these properties in cuttlebone makes it alluring for bone auxiliary materials, for the most part as formats for tissue regeneration. It can straightforwardly substitute bone tissue for bone deformity fix in a load-bearing bone site because of its magnificent mechanical quality. The structure organization, crystallography, and its mechanical-structural investigation have been contemplated in detail. Cuttlebone performed strikingly well when utilized as a xenograft for the treatment of a bone imperfection in a male rabbit model as it demonstrated a no. of re-disease and contamination reactions and quicker bone tissue recovery. Palaveniene et al. inferred that the cuttlebone is a promising material of marine source for bone tissue building in their investigation. The biocompatibility of the readied RC/CB composite with rat hepatocytes and extensor digitorum longus muscle tissue was assessed. The got information exhibited that both the composite and cellulose framework tests were non-cytotoxic and had no harming impacts. These outcomes demonstrate that this RC/CB composite is a novel material reasonable for bone tissue-designing applications. (30)

C. Seashells

Marine shells are one group of biogenic materials made out of general carbonate with the dense custom microstructures that have been utilized for a considerable length of time in the treatment of bone defects. (31) Having phenomenal mechanical properties, basic for load-bearing in orthopedic applications, marine shells have topographical features in their innate science that bestow osteoinductive properties with an improved osteogenic response to human tissue. Having amazing mechanical properties, fundamental for load-bearing in therapeutic applications, marine shells have topographical features in their intrinsic science that bestow osteoinductive properties with an upgraded osteogenic response to human tissue. The change of seashells results in clay materials such as astri-calcium phosphates, hydroxyapatite, and calcium phosphate ceramic production, which are biomaterials for bone substitute and fillers. It has been appeared in the transformation of marine shells they hold their nano-and microstructures, which are a crucial segment, and can briefly serve in an auxiliary limit with regards to bone fix and drug delivery applications. (31)

IV. WOOD DERIVED SKELETONS

Rattan wood has solid morphological comparability with bone being described by an all out porosity of 85 vol% and enormous macropores with a breadth around 250 lm composed in an arrangement of channels (imitating the Haversian systemin bone) interconnected with a system of littler canaliculi (copying the Volkmann framework).(32)

Numerous ligneous species show a permeable and progressively composed structure exceptionally near that of cancellous bone. In this way, local or semi-handled wood products might be effectively utilized as formats for producing bone-like permeable pottery by methods for a succession of change forms, which by and large include pyrolysis pursued by an hydrothermal treatment. Specific wood structures could in a perfect world imitate distinctive bone bits portrayed by various porosity and pore circulation, for example, cortical and trabecular bone.

Thus, Rattanwood is a promising format to reenact the elements of long bones, gave that a biomimetic calcium phosphate stage and the nearby propagation of the microstructure are acquired. Over 10 years, Tampieri and her associates committed numerous endeavors to build up a procedure of biomorphic change of Rattan wood in bone-like hydroxyapatite.

In vitro investigation using MG-63 osteoblast-like cells confirmed the excel(ent biocompatibility of the material and primary in Vivo tests, carried out in rat's critical femoral defects, showed extensive bone formation inside the scaffold channels devoid of any inflammation or formation of a connective capsule at1month of follow-up. (32)

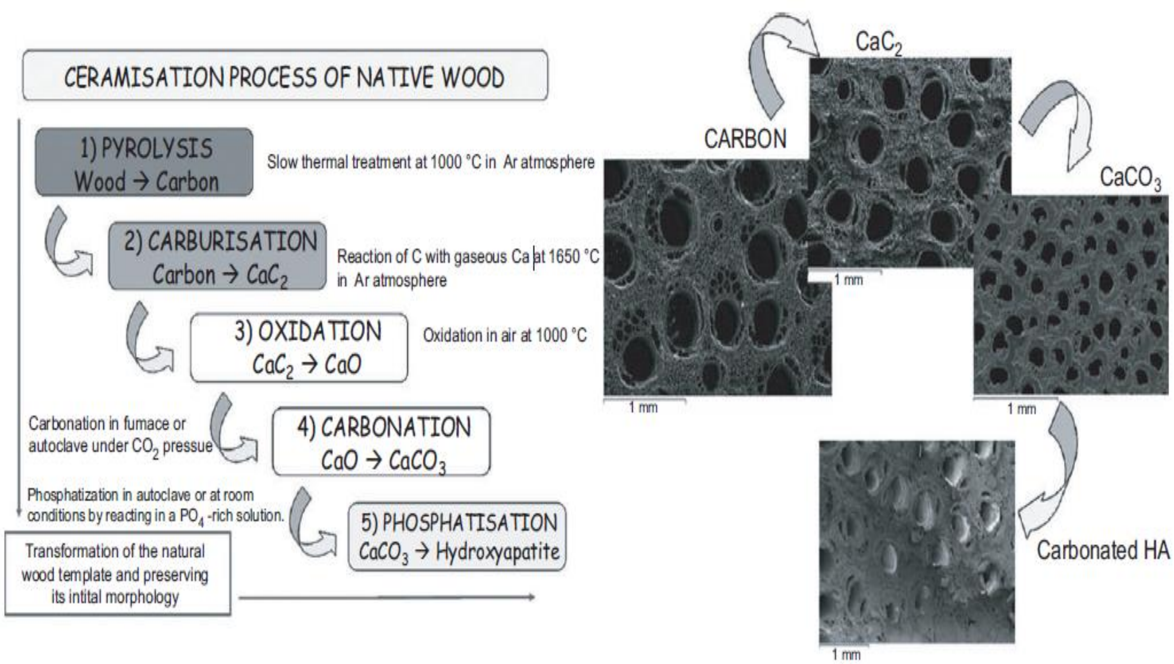

Fig 2:- Multistep transformation of Rattan wood in bone-like hydroxyapatite scaffolds (left: scheme of the process; right: SEMmicrographs of biomorphic intermediate products) (images adapted from Sprio et al.71 © Elsevier)

Wood-determined cellulose sponges likewise utilized as biotemplates to deliver permeable hydroxyapatite. Precise control of the thickness of the ceramic slurry permitted the creation of hydroxyapatites scaffolds with anisotropic porosity, which was very identical to the pore inclinations in cancellous bone.The modulation of the pore circulation and size inside the ceramic construct allowed the change between cancellous and cortical issue that remains to be worked out effectively impersonated.

V. CONCLUSION

- *In the recent years many bone substitutes have been introduced to modify, enhance, repair, and fill in the treatment of bone defects of implant treatment patients or peri implant/periodontal complications or infections.*

The review has tried to cover ecological products potential as a bone graft materials and how they have the ability to help in the treatment of the bone defects and repair of the same. These products if taken into consideration and manufactured in a desired way may solve many collateral problems that pertain to other bone grafting alternatives. It is important to understand that characteristics of different materials with reference to their crystallinity, porosity, particle size, ph, chemical structure should match with bone structure in order to select suitable material or combination. The structural similarities of the ecograft materials to bone are extremely advantageous as they may either help in treating existing bone defects or may be used in fabrication of new bone materials. Keeping this in mind, we can and should make complete use of the abundance of sources for the wellbeing of the mankind by providing groundbreaking results with these excellent biomaterials.The futureof dentistryand the use of these natural products depends on our willingness to learn and exist in the ecosystem.

REFERENCES

[1]. Fernandez de Grado G, Keller L, Idoux-Gillet Y, Wagner Q, Musset A-M, Benkirane-Jessel N, et al. Bone substitutes: a review of their characteristics, clinical use, and perspectives for large bone defects management Journal of tissue engineering. 2018.

[2]. Macha, I.J.; Cazalbou, S.; Ben-Nissan, B.; Harvey, K.L.; Milthorpe, B. Marine structure derived calciumphosphate-polymer biocomposites for local antibiotic delivery. Mar. Drugs 2015, 13, 666–680.

[3]. Macha, I.J.; Ozyegin, L.S.; Chou, J.; Samur, R.; Oktar, F.N.; Ben-Nissan, B. An Alternative Synthesis Methodfor Di Calcium Phosphate (Monetite) Powders from Mediterranean Mussel (Mytilus galloprovincialis) Shells.J. Aust. Ceram. Soc. 2013, 49, 122–128.

[4]. White RA, Weber JN, White EW. Replamineform: a new processfor preparing porous ceramic, metal, and polymer prostheticmaterials. Science. 1972;26:922-924.

[5]. Atlan, G.; Balmain, N.; Berland, S.; Vidal, B.; Lopez, É. Reconstruction of human maxillary defects with nacre powder: Histological evidence for bone regeneration. C. R. Acad. Sci. 1997, 320, 253–258.

[6]. Shim, K.-S.; Kim, S.E.; Yun, Y.-P.; Jeon, D.I.; Kim, H.-J.; Park, K.; Song, H.-R. Surface immobilization ofbiphasic calcium phosphate nanoparticles on 3D printed poly(caprolactone) scaffolds enhances osteogenesisand bone tissue regeneration. J. Ind. Eng. Chem. 2017, 55, 101–109.

[7]. Macha, I.J.; Cazalbou, S.; Ben-Nissan, B.; Harvey, K.L.; Milthorpe, B. Marine structure derived calciumphosphate-polymer biocomposites for local antibiotic delivery. Mar. Drugs 2015, 13, 666–680.

[8]. Chou, J.; Ben-Nissan, B.; Green David, W.; Valenzuela Stella, M.; Kohan, L. Targeting and DissolutionCharacteristics of Bone Forming and Antibacterial Drugs by Harnessing the Structure of MicrosphericalShells from Coral Beach Sand. Adv. Eng. Mater. 2011, 13, 93–99.

[9]. Green, D.W.; Ben-Nissan, B.; Yoon, K.S.; Milthorpe, B.; Jung, H.-S. Natural and Synthetic CoralBiomineralization for Human Bone Revitalization. Trends Biotechnol. 2017, 35, 43–54.

[10]. Ben-Nissan, B.; Choi, A.H. Sol-gel production of bioactive nanocoatings for medical applications. Part 1: Anintroduction. Nanomedicine 2006, 1, 311–319.

[11]. Ben-Nissan, B.; Macha, I.; Cazalbou, S.; Choi, A.H. Calcium phosphate nanocoatings and nanocomposites,part 2: Thin films for slow drug delivery and osteomyelitis. Nanomedicine 2016, 11, 531–554.

[12]. Francesco Baino, Monica Ferraris. "Learningfrom Nature: Using bioinspired approaches and natural materials to make porous bioceramics",International Journal of Applied Ceramic Technology, 2017

[13]. Pike L, Slade JF III, Katz LD. Augmentation of distal radiusfracture fixation with coralline hydroxyapatite bone graft substitute.J Hand Surg Am. 1999;24:816-827

[14]. Doherty, M.J.; Schlag, G.; Schwarz, N.; Mollan, R.A.; Nolan, P.C.; Wilson, D.J. Biocompatibility of xenogeneicbone, commercially available coral, a bioceramic and tissue sealant for human osteoblasts. Biomaterials 1994,15, 601–608.

[15]. Guillemin, G.; Patat, J.L.; Fournie, J.; Chetail, M. The use of coral as a bone graft substitute. J. Biomed. Mater.Res. 2004, 21, 557–567.

[16]. Ben-Nissan, B.; Milev, A.; Vago, R. Morphology of sol-gel derived nano-coated coralline hydroxyapatite.Biomaterials 2004, 25, 4971–4975

[17]. Green, D.W.; Lai, W.-F.; Jung, H.-S. Evolving Marine Biomimetics for Regenerative Dentistry. Mar. Drugs2014, 12, 2877–2912

[18]. Boccardi E, Philippart A, Juhasz-Bortuzzo JA, NovajraG,Vitale-Brovarone C, Boccaccini AR. Characterisation of bioglassbased foams developed via replication of natural marinesponges. Adv Appl Ceram. 2015;114:S56-S62.

[19]. Birchall, J.D.; Thomas, N.L. On the architecture and function of cuttlefish bone. J. Mater. Sci. 1983,18, 2081–2086

[20]. Kolk, A.; Handschel, J.; Drescher, W.; Rothamel, D.; Kloss, F.; Blessmann, M.; Heiland, M.; Wolff, K.-D.;Smeets, R. Current trends and future perspectives of bone substitute materials—From space holders toinnovative biomaterials. J. Cranio-Maxillofac. Surg. 2012, 40, 706–718.

[21]. Tampieri A, Sprio S, Ruffini A, Celotti G, Lesci IG, RoveriN.From wood to bone: multi-step process to convert wood hierarchicalstructures into biomimetic hydroxyapatite scaffolds forbone tissue engineering. J Mater Chem. 2009;19:4973-4980.

[22]. Sprio S, Ruffini A, Valentini F, et al. Biomimesis and biomorphictransformations: new concepts applied to bone regeneration.JBiotechnol. 2011;156:347-355