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The Use of Coral Scaffold in Oral and Maxillofacial Surgery: A Review

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Abstract

In recent years, there has been interest on the fabrication of system using particulates or block based approach for bone tissue engineering scaffold possessing porous interconnected structures. This article presents finding from a systematic review to describe the use of natural coral bone graft in oral and maxillofacial surgery. Literature search was conducted in the electronic database PubMed. Using the keyword Biocoral in the initial search, we found 52 articles, after exclusion 19 articles were reviewed. All the reviewed papers suggested further exploring and seeking the ideal material property that should be added to coral scaffold to improve its use.


Keywords: Biocoral, calcium carbonate, bone graft, biodegradable, scaffold.

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Introduction

Repair of defect in oral and maxillofacial surgery caused by trauma, infection or cancer is a continuous challenge in reconstructive surgery. Various grafting materials have been used in oral and maxillofacial surgery. Autogenous bone grafts are still considered the gold standard for bone reconstruction because they have the three elements for osteogenesis which are osteoconductivity, osteogenicity, and osteoinductivity. However, this kind of graft is associated with numerous limitation, including extra-surgery time, post-operative pain, hematoma formation, blood loss, nerve injury, and infection. Therefore, bone-graft substitutes represent an efficient alternative to natural tissues in the treatment of bone defect.

There are concerns that some biomaterials may cause a foreign body reaction. Tissue engineering has received increasing attention as a method for creating bioartificial tissues and organs. The spatial distributions of cells within the scaffold are one of the factors that affect the quality of tissue-engineered constructs. Optimal bone graft performance requires a scaffold architecture that can fulfill several functions such as resorption bone ingrowth or mechanical support.

Various biomaterial has been used in clinical or experimental dentistry. Metals, ceramics and polymers have been predominant in fixing and replacing the major hard tissues in oral and maxillofacial surgery. Other materials being studied are self-assembled, nanofibrous, nanoparticulate that will eventually provide natural levels of biomimetic sophistication but they are technically difficult syntheses. Marine biomimetic structures offer useful advantages before the future onset of truly biomimetic artificial designs, due to their sophisticated pre-design of structure and architecture.

Coral skeletons have been used as bone substitutes in surgery. A pioneering idea for harnessing coralline materials in medicine involves an innovative process for transforming and generating high fidelity copies of marine skeletons such as coral. Coral is composed of calcium carbonate in the form of aragonite. It has achieved considerable success in bone graft application because of its large porosity and uniform pore size combined with mechanical strength. Only a few general of corals meet the
required standards of pore diameter and connectivity. Further studies were carried out to assess tissue growth responses to these new implants. Now there are many published studies attesting to various levels of clinical efficacy to heal widely separated fractures and fill naturally unbridgeable bone voids caused by tumors for example. Bone tissue morphogenesis has been augmented within coral skeletal frameworks by incorporating bone marrow derived stem cells with impressive outcomes. Even though it is difficult to define the ideal scaffold architecture for a bone graft, some scaffolds do perform very well in clinical application. One typical example is coralline hydroxyapatite which is a viable option for bone defect. It is well known that calcium carbonate, the natural component of coral, is more soluble than hydroxyapatite. This article presents finding from a systematic review to describe the use of natural coral bone graft in oral and maxillofacial surgery.

Materials and methods

Literature search was conducted by one author. As our aim was to scope the current use of biocoral in dentistry, we were seeking to generate a broad question, and key terms were the main focus. The question “How does the use of Biocoral scaffolds developed in oral maxillofacial surgery?” guided the search strategy. MeSH was used to obtain the correct terms for keywords. Further into this study, key search terms were identified and a Boolean search string developed. Using truncated words (in this case * ) we aimed for a search that would capture all terms with the same root word. Our final string was biocoral * AND calcium carbonate* AND bone graft* AND biodegradable * AND scaffold. An initial search of Google Scholar was carried out to determine the relevance of the key terms, but google scholar was not used as the search engine in this study due to the irre replicability of this search engine. To determine an appropriate time frame for the review, the Google Scholar search located biocoral in oral and maxillofacial surgery prior to 2002 so this date was chosen as appropriate for this study. Databases searched included PubMed. Inclusion and exclusion criteria, consistent with our review purpose, were developed and are outlined in Table 1. The full papers of the selected publications were obtained. Table 2 is the studies related to this review.

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<td>Any study outside the dates</td>
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<td>Review</td>
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<td>International studies including those with specific cultural groups</td>
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<td>Sample</td>
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<td>Clinical trial</td>
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<td>Retrospective study</td>
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Table 1. Inclusion and exclusion criteria.

Results

Using the keyword Biocoral in the initial search, we found 52 articles, 14 of which were published in the last 10 years, and 6 articles were excluded due to irrelevance towards this review. We then continued the search using biocoral AND calcium carbonate, we found 26 articles, this time 8 articles were published in the last 10 years. We used a combination of calcium carbonate AND bone graft as keywords and found 151 articles, with 82 articles being published in the last 10 years. Afterwards, we combined the search using calcium carbonate AND biodegradable as keywords and we found 77 reports and 49 were published in the last 10 years. The combination of calcium carbonate AND biodegradable AND scaffold resulted in 12 articles, 10 of which were published in the last 10 years (Figure 1). Finally, we found 19 articles that were full papers. Ten articles were invitro and describe the characteristic coral as a scaffold and comparison with various material, single and combination use as composite to improve the effectiveness of coral, 5 articles were invitro describing bone formation and the healing process, 3 articles were clinical trial using biocoral describing osteogenesis process, 1 article was retrospective study using medical records to analyze postoperative complications after implantation.
The interest in natural coral exoskeletons has been increasing because natural coral exoskeletons give reduced risk of disease transmission and viral contamination compared with bovine graft. Nonetheless, unconverted coral is unsuited for most long-term implants because of its high dissolution rate, poor longevity and poor stability. High degradation rates have also been found at low pH values (5.0–6.5), which are normally associated with infections and inflamed tissues. To overcome the limitation, corals have been converted into hydroxyapatite (collarine hydroxyapatite) by hydrothermal exchange or microwave processing, leading to products with improved resorption rates and better osteointegration. In this treatment, hydroxyapatite partially replaces aragonite while preserving the porous structure. However under certain circumstances, a decrease in structural strength may be observed. This problem can be reduced through the use of double-conversion techniques (conversion to coraline apatite followed by so-gel nanocoating).

Further, it is well known that calcium carbonate, the natural component of coral, is more soluble than hydroxyapatite. By controlled conversion of the proportion of calcium carbonate in coral into hydroxyapatite, the biodegradation of the resultant collarine hydroxyapatite/calcium carbonate composition can be modified.

Another article reported that calcium carbonate was demonstrated to be clinically suitable for sinus augmentation procedures of the atrophic posterior maxilla after a 1-5 year time period, histologically biocompatible, and osteoconductive. Further studies are needed to assess the scaffold behavior with longer follow-up period and a larger sample size.

Moreover, an in vitro study reported that bone regeneration may have different interactions with different bone replacement material tested in vitro. Although autogenous bone was defined as gold standard, but both DFDB and Biocoral compared favorably. Since even the sterilization of DFDB cannot exclude the possibility of disease transmission, Biocoral may be considered a recommendable material. Other study reported that Micro-CT

Figure 1. Flowchart of literature search and selection.

The majority of the studies (11/19) compared coral or calcium carbonate with others material and some other studies added additional material to the existing coral. Moreover stemcells were added as an additional material in three studies. Two articles presented the need of antibiotic in calcium carbonate graft. One article explained the importance of sample size and the other one said about the advanced evaluation of characteristic of collarine-derived scaffold graft using micro-CT. Further, one article presented retrospective study in the past 10 years regarding postoperative complication using coral implant compared with other material.

Numerous biomaterials have been successfully used as bone substitutes, such as alloplast, xenograft, natural and synthetic calcium-based materials, and a combination of these. Recently, research on biomaterials emphasizes the creation and characterization of new material and enhancement of existing material would be degraded at the same rate as new bone is formed and would be at least osteoconductive and possibly osteoinductive.
technique can be used in advanced for characterization of bone tissue engineering constructs because it is noninvasive and nondestructive, a complete, precise, and high-resolution three-dimensional analysis of their microstructural parameters.2,3

The studied materials showed both the capability of degrading and bioactive properties due to their innovative porous morphology as demonstrated by early osteogenesis.2,6 These materials may be proposed as osteoconductive because the clearly accelerate bone defect healing and preserve alveolar bone dimensions and architecture after tooth extraction. This goal is important for clinicians to obtain good aesthetic result in both conventional and prosthetic implant rehabilitation.14 With these in mind, commercial samples of materials currently used in dentistry were observed. Regard to the osteoclastic chemical composition, the tested samples can be divided into two groups: one comprising the hydroxyapatite-based materials and the other constituted only by Biocoral, a calcium carbonate (aragonite) material. However, even for those with similar chemical characteristics, significant differences were detected in terms of particle size, crystalline orientation, size, distribution, surface, and mineral content.3,6

Although these morphological characteristics greatly influence the in vivo behavior of the samples, they are often not taken into consideration when the samples biological performance is evaluated. This may be responsible for the conflicting results frequently found in the literature. It is believed that the results provided for the materials investigated will be most useful to fully interpret their clinical responses.5 Nonetheless, many important questions regarding the predictability of sinus augmentation procedures remain unanswered. However one study may confirm that different materials can be safely used, and depending on the needs and preference of the clinician, choice should be directed to one or the other. In each case, selection of the appropriate biomaterial has to be performed knowing its properties and ultimate fates, considering advantages and disadvantages, and keeping in mind that we may expect predictable result and clinical success.30

While Guided Tissue Regeneration promoted new bone formation, the calcium carbonate implant contributed limited, if any, osteoconductive effects.7

The biocompatibility and osteoconductivity of SS3P4 bioactive glass, allogeneic bone and coral-derived calcium carbonate suggest that bioactive glass SS3P4 can be considered as better bone filler than coral-derived calcium carbonate, which is resorbed too quickly, thus making it less ideal material for filling cavitory defects.14 The role of calcium carbonate in bone scaffolds is not only to provide mechanical support, but also to improve biodegradation properties.3 The results of the recent in vitro study demonstrate the high potential of the combination of eggshell particles and hyaluronan a basic components for bone regeneration and tissue engineering. In this study the addition of hyaluronan to eggshell particles enhances the osteogeneic differentiation of the cells, shown by the immunohistochemical staining, 2,6,14 These results correspond with the finding of other studies, where beneficial effects concerning matrix mineralization, cell differentiation and osteocalcin regulation were shown.18 Different composite materials consisting of poly-(D,L-lactide), B-tricalcium phosphate, and calcium carbonate were manufactured as candidates for degradable bone substitutes. The investigations about the bending strength indicated suitably high values for the composites materials. The critical aspects were the huge amount of swelling of the polymeric matrix and thus the reduction on the bending strength during storage in water and PBS. A swelling and thereby a volume increase, could be critical especially for use of the tri phase bone substitute compound as a 3 D scaffold with defined dimensions. This must be taken into account with respect to the composition of the compound and the scaffold design.30

A novel facile MCCs to be used as bone grafts were prepared under the low-temperature condition. The MCC50 possessed highest compressive strength, while MCC100 with largest amount of magnesium amount of magnesium encountered deteriorated mechanical strength. The in vitro degradation of MCCs accelerated with increasing amount of introduced magnesium. The MCCs showed excellent cytocompatibility. The MSCs cultured on MCCs with a certain amount of magnesium (MCC50, MCC75, and MCC100) exhibited more ascendant proliferation and osteogenic differentiation compared to MCCo. Given the poor mechanical strength of MCC100, the MCC50 and MCC75 are currently
considered to be optimal biomaterials as potential bone grafts. Further exploration and analysis to obtain ideal materials was conducted. For example, a study has shown that automated serial optical sectioning using structured illumination FM can assess cell numbers and the 3D distribution of hBMSCs in mineralized scaffolds. This allows for detailed analysis of the effect of different in vitro procedures used for cell seeding. The use of a fibrin matrix during seeding increases seeding efficiency and enhances both proliferation and cell survival in the central parts of the scaffolds. The results of the present study indicate that a biocorall scaffold combined with BMSCs enhanced by BMP2 can repair the critical-sized orbital defects in a canine model suggesting that this method could be a feasible approach for the clinical reconstruction of orbital bone defects. Furthermore, the effects on the interaction between osteogenesis and angiogenesis were observed and substantiated by ELISA assay. Taken together, our result provide clear evidence that DPSCs can enhance to osteoblast, forming a biocomposite made of Biocoral, ECM and differentiated cells.

Another study confirmed the ability of bone grafts to act as antibiotic carriers. Bone chips mixed with HERAFILL showed efficacy against S. aureus and S. epidermidis. Further studies with HERAFILL as bone void-filling material are needed. The susceptibility test using S. aureus show less resistance of the strain after 1 month of the elution storage. That resistance was not observed after 6 months of storage. The capacity of bone grafts to act as gentamicin carriers has been confirmed in this study. The different granules sizes did not interfere in the delivery rate of the antibiotics or in the activity against the bacteria. Storage at -80°C does not interfere on the antibiotic activity.

Conclusions
The existing studies are still exploring additional materials to improve the ideal characteristics of coral as a scaffold. These studies are comparing coral with other materials, and added coral with other materials or stem cell to improve its effectiveness. Various materials can be used depending on the needs and preference of the clinician. In each case, selection of the appropriate biomaterial has to perform knowing its properties and ultimate fates, considering advantages and disadvantages, and keeping in mind that we may expect predictable results and clinical success.

Declaration of Interest
The authors report no conflict of interest and the article is not funded or supported by any research grant.

References
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<th>Compared Material</th>
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<tr>
<td>Drevoglu D. Tütüncü T. F., Sengün D., Nuhutlu R.M.¹</td>
<td>2004</td>
<td>Biomaterials in periodontal regenerative surgery: effects of cryopreserved bone, commercially available coral, and mineralized freeze-dried dentin on periodontal regeneration</td>
<td>Journal of Biomaterial Application</td>
<td>To evaluate effects of different biomaterials, demineralized freeze-dried dentin, and cement on periodontal regeneration</td>
<td>1</td>
<td>In vitro</td>
<td>Proliferation Assay, Protein Assay</td>
<td>15-35 days</td>
<td>cryopreserved bone allograft(BLA), coral, hydroxyapatite (CHA), demineralized freeze-dried dentin (DFD), cement</td>
</tr>
<tr>
<td>Kuo KT, Pulimire Q., Qahash M., Kim CK, Wiajo LM.²</td>
<td>2005</td>
<td>Periodontal repair in dogs: guided tissue regeneration enhances bone formation in sites implanted with a coral-derived calcium carbonate biomaterial</td>
<td>Journal of Periodontaliology</td>
<td>To evaluate bone formation associated with the CI biomaterial in the presence and absence of provisions for GTR</td>
<td>12</td>
<td>In vivo</td>
<td>Histological and Histometric analysis</td>
<td>4 weeks</td>
<td>CI and CI/GTR</td>
</tr>
<tr>
<td>Pretorius J.A., Melen B., Nel J.C., Garmishya P.J.³</td>
<td>2005</td>
<td>A histomorphometric evaluation of factors influencing the healing of bone defects surrounding implants</td>
<td>International Journal of Oral and Maxillofacial Implants</td>
<td>To perform a histomorphometric study of the healing of bone defects created adjacent to titanium and hydroxyapatite (HA)-coated implants and covered with either a resorbable or a non-resorbable membrane in combination with different filler materials and to evaluate to what degree coating, membrane, and/or filler influenced the healing defects</td>
<td>10</td>
<td>In vivo</td>
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<td>3, 6, 9, 12, or 18 months</td>
<td>semineralized freeze-dried bone (DFD), autogenous bone, bioceramics</td>
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<tr>
<td>Scarna RN., Degidi M., Iezzi G., Pecore G., Piattelli M., Crisci D., Caputi S., Pietrini V., Manganaro G., Piattelli A.⁴</td>
<td>2006</td>
<td>Maxillary sinus augmentation with different biomaterials: a comparative histologic and histomorphometric study in man</td>
<td>Implant Dentistry</td>
<td>To compare different materials in maxillary sinus augmentation in man</td>
<td>Human 94</td>
<td>6 month</td>
<td>Biomechanical and Histomorphometric study</td>
<td>6 month</td>
<td>DPDSO (Lifelast, Virginia Beach, VA), Bioact, Bioact Graft (German, Bologna, Italy), Pegaso, P-15TS, calcium sulfate (Silicon scaffold: Class</td>
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<tr>
<td>Analysis of the Postoperative Outcome in 405 Cases of Orbital Fracture Using 2 Synthetic Orbital Implants</td>
<td>2006</td>
<td>Nam, Su-Bong MD, Bae, Yong-Chan MD, PhD; Moon, Jae-Sul MD, Kang, Young-Seek MD</td>
<td>Annals of Plastic Surgery</td>
<td>To analyze the postoperative complications. According to the location (floor / medial wall / roof and medial wall) of the orbital fracture of 405 Patients during the past 10 years and to investigate the possible alternative of data in post-operative outcomes in change with the application of two synthetic orbital implants: porous polyethylene (Medora) and hydroxyapatite (BioCoral).</td>
<td>405 medical records postoperative outcome after using 2 implant 10 years past porous polyethylene (Medora) and hydroxyapatite (BioCoral)</td>
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<tr>
<td>In vivo preclinical efficacy of a PDLA/PGA porous copolymer for dental applications</td>
<td>2009</td>
<td>Techino M, Pina M, Gavaret G, Remonding L, Ambrosio L, Giordano R</td>
<td>Journal of Biomedical Materials Research A</td>
<td>To analyze surface morphology and physical-chemical properties of a copolymer of polyactic polyglycolic acid (Tissocraft, Ghimas) 12 in vivo (SEM, porosimetry, and rheological analysis)</td>
<td>porus polymer in SPONGE or GEL form and compared with commercial BioOss</td>
<td>15, 30, 60 days</td>
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<tr>
<td>Physicochemical characterization of biomaterials commonly used in dentistry as bone substitutes -comparison with human bone</td>
<td>2010</td>
<td>Figueiredo M, Henriques J, Martinh G, Guerra F, Judas F, Figueiredo H</td>
<td>Journal of Biomedical Materials Research A</td>
<td>To analyze the physico-chemical characterization of selected mineral-based biomaterials that are frequently used in dental application</td>
<td>BiOss1 and PepGen P-151, porcine (OsteoBiol 1), and coraline (BioCoral1) compared with human bone</td>
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<td>Human bone marrow stroma stem cell distribution in calcium carbonate scaffolds using two different seeding methods.</td>
<td>2010</td>
<td>Zhu H, Schultz J, Schleghake H</td>
<td>Clinical Oral Implants Restoration</td>
<td>To develop a method for the determination of the three-dimensional (3D) distribution of cells in mineralized scaffolds and to compare the effect of two different methods of cell seeding of human bone marrow stroma cells (iBMSCs) in iBMSCs were seeded into CaCO3 scaffolds by droplet seeding using culture medium with and</td>
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<td>Authors</td>
<td>Title</td>
<td>Journal</td>
<td>Volume</td>
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<td>Results/Conclusions</td>
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<td>2011</td>
<td>Mangano C, Piard F, d’Aquino R, De Rosa A, Iezzi G, Piattelli A, Lam L, Mitsiadis T, Desiderio V, Mangano F, Papacoda G, Torino V</td>
<td>Human dental pulp stem cells hose into binocular sc afford forming an engineered bone comprised of PSCs</td>
<td>PloS One</td>
<td>6</td>
<td>10</td>
<td>e23430</td>
<td>To evaluate the behavior of human Dental Pulp Stem Cells (DPSCs), as well as human skin cells, when challenged on a Biocorall scaffold, which is a porous natural hydroxyapatite</td>
<td>Biocorall Human Osteoblast control</td>
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<td>2013</td>
<td>Fu J, Xu Q, Cormack J, Griffin J, Jia Z</td>
<td>Characterization of a biodegradable biocomatble</td>
<td>Biomedical Materials</td>
<td>18</td>
<td>3</td>
<td>22-33</td>
<td>To characterize CHO/HCl to assess its capacity for productive</td>
<td>In vitro human</td>
<td>In vitro</td>
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<td>2013</td>
<td>Guia M, Rosas J, Hinojosa J, Ako AJ</td>
<td>Comparison of the osteoconductive properties of three particulate bone fillers in a rabbit model: allograft, calcium carbonate (Biocorall), and SS3P4 bioactive glass.</td>
<td>Acta Biomaterialia</td>
<td>31</td>
<td>1</td>
<td>35-46</td>
<td>To compare the osteoconductive and suitability of three biomaterials used as particulate fillers: SS3P4 bioactive glass, allogeneic fresh frozen bone and coral-derived calcium carbonate.</td>
<td>Rabbit 69 specimens from 43 knees of 21 adult rabbits</td>
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<td>2014</td>
<td>Cusano, Huber G, Hasebe S, Fita M, Noto B, M, Kuhn KD</td>
<td>Calcium carbonate powders maintaining gelatinous for mixing with bone grafts</td>
<td>Orthopedics</td>
<td>110</td>
<td>5</td>
<td>753-760</td>
<td>To evaluate the use of absorbable bone graft substitute powder as a bone void-filling material as well as an antibiotic center for mixing with bone grafts</td>
<td>Bone Chips/Heraplast</td>
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<td>2014</td>
<td>Carro, Mangano A, Piattelli A, Jami, Ansell S</td>
<td>Clinical and histologic evaluation of Calcium Carbonate in</td>
<td>Journal Periodontics</td>
<td>9</td>
<td>6</td>
<td>590-596</td>
<td>To evaluate a clinical, histologic and histophenomeric of calcium carbonate in sinus elevation.</td>
<td>Calcium carbonate</td>
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| He et al. | 2015 | A foam magnesium-containing calcium carbonate biomaterial as potential bone graft | Collodial and structural biodegradable scaffold 
Biointerfaces | In vitro SEM, X-ray spectroscopy | 3 in vitro 
3 in vitro 
3 in vitro 
3 in vitro 
3 in vitro |
| Neuzenhofer et al. | 2015 | Eggshells as natural calcium carbonate source in combination with hyaluronic acid as beneficial additives for bone graft materials | Head 
Face Medicine | In vitro Proliferative light microscopy and 
Countdown at defined positions 
Histology and immune histochemistry | Proliferative light microscopy and 
Countdown at defined positions 
Histology and immune histochemistry |
| Curia et al. | 2015 | Antibiotic-loaded calcium carbonate/calcium sulfate granules as co-adjuvant for bone grafting | Journal of Materials Science | In vitro Drug release test 
& bacterial susceptibility in 
Human osteoblasts | No storage loss 
Bacterial susceptibility in 
Human osteoblasts |
| Alberti & Amela et al. | 2015 | Degradation & Preparation | POLYATOC | In vitro | 3 in vitro 
3 in vitro 
3 in vitro |
| | 2015 | Swelling issues of poly(3-hydroxyalkanoate)/calcium phosphate/calcium carbonate composites for bone replacement | Journal of Biomedical Materials | Homogeneous composite material for bone replacement | weeks |

Table 2. Overview of studies included in the review.