

The Effect of Using Different Types of HA on Compressive Strength of HA/MWCNTs-OH/BSA Composite for Use as Bone Replacement Materials

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Editorial

The adult human body has 206 bones while for a baby has more than 300 bones. So what happens to the rest of the bones while the baby grows up? [1]. This is due to the bones fuse together till only 206 bones are left. Without bones, the human body would not have the shape which is seen by others. It would have no power to move, sit or stand [2].

Bone is a complex building material that is mainly made by an organic protein; collagen and the inorganic mineral hydroxyapatite, which combine to provide a mechanical and supportive role in the body [3]. Depending on the orientation of collagen fibers, two types of bone can be distinguished: cortical bone and trabecular bone. Around 30% of bone is composed of organic compounds, of which around 95% is collagen, and the rest is non-collagenous protein. Collagen is a fibrous protein which provides the bone with strength and flexibility, and is a very important component of many other tissues [3]. Bone is a composite material and contains 10% water, 20% organic material, and 70% mineral matter [4]. The organic component consist mainly collagen fibrils and the remainder of the organic material is cement-like substance and a cellular component, comprised of osteocytes, osteoblasts, and osteoclasts, which aid in dissolution, deposition, and nourishment of the bone, respectively. The inorganic, mineral material of bone is a calcium deficient carbonate-substituted apatite containing calcium and phosphate ions, which are similar to hydroxyapatite (HA, $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$) in structure and composition [5].

Besides, bone is a rather unique tissue with many functions. All bones have a mechanical function providing attachment to various muscle organs. Furthermore, in some parts of the body, bones provide a protective function to vital structures such as skull (brain), ribs (lungs, heart) and pelvis (bladder, pelvic viscera). Some bones retain their hematopoietic function in adults such as vertebrae, iliac crests, proximal parts of femur and humerus. All bones serve as a reservoir of calcium and actively participate in calcium homeostasis of the body [6].

Bone consists of living tissues that rebuild constantly throughout our life. During human young age, body adds new bone faster than it removes old bone. After about age 20, rate of loss bone is faster than the make bone. In order to prevent bone loss at older ages, the only way is to get enough calcium, vitamin D and exercise [7]. The most common bone disease is osteoporosis, which is characterized by low bone density and deterioration of bone structure. Osteoporosis happens when bones lose minerals, like calcium, that make them strong, and as a result, bones become weak and fracture easily [7,8]. Other bone diseases include osteogenesis imperfect and Paget's disease. Osteogenesis imperfect is an inherited disorder that causes brittle bones and frequent fractures in children. Paget's disease affects older men and women, and causes the bones to grow larger and weaker than normal [8].

Due to the accident or bone diseases, whole bone parts must often be repaired or even replaced. It is very important to provide a scaffold for the body cells that allows rapid growth while simultaneously keeping the general shape of the tissue. Bone replacement materials are used to

develop porous scaffolds to mimic the structure and composition of the natural bone. There are various types of bioactive composite that have been investigated over the last 20 years as bone replacement materials for diseased or damages tissues in human body. HA is a naturally occurring mineral form of calcium apatite, it is chemically similar to the mineral component of bones and hard tissues in mammals. HA is one of few materials that are classified as bioactive [9]. That is why synthetic HA particles, film, coatings, fibers and porous skeletons are used extensively in various biomedical applications.

HA plays a very important role in development of bone replacement materials because of its unique properties. HA is non-toxic, biocompatible and bioactive component where it can support growth of osteoblasts on surface of bone replacement materials. However, application of HA based bone replacement materials is limited to the low-stress region due to its relatively low mechanical properties [10,11]. Nowadays, many researches are carried out to improve the mechanical properties of HA based composite without neglecting its bioactive performance. Zhou and Lee [12] described that the physical properties of HA particle are another important key that affect its mechanical properties and simulate osteoblastic proliferation compared with normal HA. Besides, recent advancements in nanotechnology and nanoscience have reignited investigation on effect of nanoscale HA powder toward prepared composite. Hence, the purpose of this study is to investigate the effect of using different types of HA in HA/MWCNTs-OH/BSA composite.

The HA/MWCNTs-OH/BSA composites were prepared by physical mixing of HA with de-ionized water, 0.5 wt.% of hydroxylated MWCNT-OH and 15 wt.% of BSA to produce the HA/MWCNT-OH/BSA composites. The materials were blended until a homogeneous paste was obtained and then firmly packed into a cylindrical stainless steel mould (diameter=6 mm and length=12mm) of prepared cylindrical specimen. The packed stainless steel mould was wrapped with a water-soaked wipe to prevent the sample from drying out and was then stored in an incubator at 37°C and 97% humidity for 24 h. Then, the samples were taken out and dried at room temperature. 4 different types of HA were used for preparing the samples. The compressive strength was test using an Instron 3367 universal testing machine at a crosshead speed of 1.0 mm/min.

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Table 1 show that the HMB-2 composite which consist of 84.5 wt.% nanoHA powder achieve highest compressive strength, 8.66 MPa. This value is slightly higher than compressive strength of the composite HMB-1 which consists of 84.5 wt.% reagent grade HA (8.03 MPa). Also, both HMB-3 (consist of 5.6% nanoHA dispersed in water and HA nano-powder) and HMB-4 (consist of 5.6% nanoHA dispersed in water and reagent grade of HA) show relatively low compressive strength. There are some challenges to be overcome during preparation of HA/MWCNTs-OH/BSA composites. Cement paste was blended continuously in order to break down agglomeration of HA powders so that it can distribute evenly with MWCNTs-OH and BSA. However, it is difficult to break down all agglomeration of powder, different type of HA powder have different agglomeration affinity [13], thus, agglomeration of HA powder might be one of factors that affect quality of HA/MWCNTs-OH/BSA composites. The good mechanical strength of HMB-2 can be justified by formation of nanocrystal structure and strong interfacial bonding between particles in the composite. Nanocrystals have high surface area that greatly supports bonding between particles of HA and MWCNTs-OH and BSA and also it can support attachment and growth of human osteoblast cells. Lower compressive strength for other composites might be due to weak bonds and presence of voids between crystals. Use of dispersed HA nano-powders to prepare the HA/MWCNTs-OH/BSA composites did not improve the quality of it due

HA/MWCNT-OH Composites	Average Compressive Strength (Mpa)
HMB-1	8.03
HMB-2	8.66
HMB-3	2.44
HMB-4	4.06

Table 1: Compressive strength of HA/MWCNT-OH composites.

to weak ability to form nanocrystal or bond with other nanoparticle. According to the results the new composite has potential for use as bone filling and tissue regeneration techniques in the future.

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