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Available and Cost Reductive Materials in Bangladesh Having an Eye to Bone Treatment

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Abstract: Bangladesh have been announced as a developing country among the countries in the world in 2018. But poverty has not yet been eradicated properly. According to the World Bank, Bangladesh's poverty rate fell from 82% in 1972, to 18.5% in 2010, to 12.9% in 2016, as measured by the percentage of people living on the equivalent of US$1.90 or less per day in 2011 purchasing power parity terms. People die due to lack of treatment every year. Labourer and old people cover a great amount of population in Bangladesh. These people are suffering or will be the sufferer of bone disease like osteoporosis, bone fracture, bone pain etc. As a result the economy of Bangladesh will be hampered greatly. Bone treatment is a material dependent technique. So the cost is dependent on the material whether it is expensive or not. People can't afford titanium but they can afford steel. If the purpose is served by using steel then these sufferers will be the beneficiaries at a low cost. In this treatment there are a several factors that should be looked into. This paper focuses on the features of cheap and very common materials that can be used for bone treatment. Steel, aluminium, zinc, ceramics are very common materials here in Bangladesh. This literature will aggrandize the bone treatment facility in Bangladesh at a low cost and will be inspiring the researcher in this sector.

Keywords: Bone treatment, Steel, Magnesium, Aluminium, Cobalt, Copper, Zinc.

1. Introduction: Bangladesh is a developing country among the 196 countries in the world. According to the survey of the year 2015 the early income per capita is 1314 USD here. Most people living here are associated to hardworking. They are vulnerable to bone related diseases such as osteoporosis, osteopenia, hip fracture etc. Most of the people living in this country can't afford higher standard medical care. It should be focused on the issue that the people get better treatment while the cost is reachable. Biomaterials are being developed all over the world with a great consensus value. There is a slight wall between materials and biomaterials. This determined that a biomaterial was 'a nonviable material used in a medical device, intended to interact with biological systems.' For bone treatment basically three type of biomaterials are used like metals, ceramics and polymers. Metals have unique and often useful bulk, surface, and biological properties, including biocompatible strain and heat transductionPolymers often degrade by hydrolysis but metals degrade in the body by either oxidative corrosion or galvanic corrosion [1-3]. Metals are available comparing to the others materials in Bangladesh. In Bangladesh Steel, Magnesium, Aluminium, Cobalt, Copper, Zinc and other metals are cheaper and easy to get. Titanium is a significant material in bone treatment but as cheap and available metals are discussed this review will not highlight Titanium. Some prolific researcher have already worked on these materials covering the field of bone treatment as they are cheap enough. This literature will review these materials having potentials to be used in bone treatment as a biomaterial for the welfare of Bangladeshi people. The most contributory aspect of this paper is to accumulate these separate studies into a single form so that the maximum benefits can be obtained at the time of selecting efficient materials simultaneously as all the available bone treatment materials are described.

2. Methodology and Materials: The key ingredient of any bone treatment system lies in the application of stable, attractive and biologically responsible materials. Biomaterials having severe destructive impacts to the body internal affairs such as functional disability, movement constraints etc by releasing infectant, toxicity and depletion of natural resources are to be avoided. The selection of the materials depends on some factors (e.g. highly efficient to the habitants, cost effective and inserting to the living subject, surface area, strength, stress etc.).

2.1 Stainless Steel: Stainless steel is a very available material in Bangladesh. It is used for different purposes. The use of stainless steel in surgical applications began in 1926. Stainless steel is considered the most common material among the metallic implants due to the low cost and the ease of fabrication [4]. It holds a benefit of being used as a cost effective biomaterial. Stainless steel is used for fracture fixation for most cases [3,5]. Stainless steel is mainly used when there is a requirement of stiffness [1]. It has higher stiffness than coral bone. In bone implant stiffness is a very important feature. The density of stainless steel is about 7.9 g/cm3 [6]. This is nearly twice the density of titanium, but this is not critical since the weight of relatively small-sized fracture fixation implants is not considered a major factor. Today's implant quality stainless steel contains 13 to 16 wt.% nickel although nickel ions are the most

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widespread skin contact allergen [6]. The elastic modulus of stainless steel for being used as implants is about 200GPa [7] .Newly developed nickel-free implant quality stainless steels combine the advantages of excellent mechanical properties which are clearly better than today's standard implant stainless steels and the absence of nickel as an allergen [2]. The release of iron from stainless steel favors bacteria infections by acting as an iron source for their proliferation [8]. To avoid this consequence stainless steel is used in the body as short term implants or is used with coating. So this material is a perfect choice for using as bone implant material as well as fixation material comparing the financial aspect of this country's people.

2.2 Magnesium: Elemental magnesium (Mg) was discovered in 1808 and Mg and its alloys have shown generating significant interest for use in biomedical applications as implants, osteosynthesis devices, ligatures, and wires for aneurysm treatment and connectors for vessel anastomosis [9]. Magnesium is also used as biodegradable alloy which dissolves in aqueous solution containing chloride ion [10,11]. Magnesium based alloys are typically 1/3 as dense as titanium based alloys and only 1/5 as dense as stainless steel and chrome-cobalt alloys. Magnesium alloys, in contrast, have a modulus of elasticity of around 45 GPa, which is much more closely matched to that of bone, thus lessening the likelihood of stress shielding and the associated loss of bone density. This feature has inspired researchers to develop a biodegradable biomaterial. Magnesium can be used as Mg-Al alloy system and Mg-RE alloy system [12]. Aluminum is well known as a neurotoxicant and its accumulation has been suggested to be an associated phenomenon in various neurological disorders as dementia, senile dementia and Alzheimer disease [13]. We all know calcium is an important material in bone. Ca has a low density (1.55 g/cm3), which endues the Mg-Ca alloy system with the benefit of similar density to bone. Magnesium possesses good biocompatibility and relatively large amounts of magnesium are tolerated by the body without ill effect. Recently, there have progress made in the direction of better performance of bone screws leading to the study of magnesium (Mg) and Mg-coated screws. So it should be understood that magnesium can be an efficient material for the solution of bone related health problem.

2.3 Copper**:** Copper is a very common material in Bangladesh serving various purposes like industrial, ornamental, experimental etc. Orthodontic brackets and wires are widely used for long span of treatments. Researchers are trying to minimize the discomfort caused by it [14]. For this purpose copper can be used as a cheap material along with titanium, nickel and others. Copper has a great advantage of being used as coating material. Copper can also be used as metallic nanoparticles along with zinc showing antibacterial activity and non-toxicity for osteoprogenitor cells [15]. Copper with NiTi wire more resistant to permanent distortion than NiTi wires [16]. So copper has a great chance to be used in orthopaedic application and more research activities in copper should be inspired for the welfare of this country's people.

2.4 Zinc: Zinc has a very interesting role in bone formation and mineralization. The effects are specifically obvious for Zn-incorporated biomaterials including bone cements [17], bioglasses [18,19], ceramics [20], and coatings [21]. Despite the established roles of zinc in bone metabolism, the feasibility of Zn-incorporated biomaterials in clinical applications are relied on many factors especially safety issues associated with the zinc content and release kinetics. Uncontrolled fast release of Zn ion can disrupt zinc homeostasis, alter the concentrations of other metals for tracing such as calcium, iron, and copper causing deficiency, and bind to low affinity sites leading to protein dysfunction [22-24]. It has been reported that the influence of Zn2þ on the osteogenic differentiation of mesenchymal stem cells (MSCs) is dependent on dose [25,26]. Therefore, it is crucial to determine the tolerable and safe upper intake level and much work has been done to investigate the optimal zinc contents in various biomaterials. Hydroxyapatite is a very useful material when it comes to bone treatment related topic. Silicon substituted and silver substituted HA have been studied. But among the candidates zinc is a very potential candidate because of it's abundancy as a trace metallic component of bone and has a very important role in bone biochemistry [27].

2.5 Aluminium: As a bio tolerant material, Aluminum is considered as the alternative solution for the natural bone for characteristics such as osteoinduction, osteoconduction, inflammation and mechanical integrity. Aluminum is used as the implant in the human bone as well as the dental implant. Ceramics from Aluminum also used as biomaterial. Alumina (Aluminum based ceramics) currently is used for orthopedic and dental implants, and has the ability to be polished to a high surface finish and high hardness. The compressive, tensile and bending strengths exceed the strength of compact bone by 3 to 5 times. These properties combined with high modulus of elasticity and especially with fatigue and fracture strength is resulted in specialized design requirements for this class of biomaterials [28]. Now, the applications for alumina encompass porous coatings for femoral stems, porous alumina spacers (specifically in revision surgery), knee prosthesis and in the past as polycrystalline and single crystal forms in dental applications as tooth implants. Alumina is also used in the head replacements of the bone. Aluminum, it's alloys, ceramics are considered to be replaced in human body as a bone or dental implants. As aluminium is used abundantly in Bangladesh further research work can pave the way to make this a revolutionary bone treating material.

2.6 Cobalt: Cobalt is used as a biomaterial for its unique properties and characteristics which allow its validity in the human body. Basically Cobalt alloys are used highly in implants. There are commonly two types of Co-Cr alloys which are used as implant materials, (i) Co-CrMo alloy which is castable and (ii) Co-Ni-Cr-Mo. Cobalt (Co) based implants have higher wear resistance compared to Ti alloys, which warrants their extensive use in artificial hip joints, where the direct contact between femoral head and the bone or plate over time may lead to wear. Clinically, Co-Cr-Mo is one of the most commonly used alloy for having high strength and high ductility [29]. While compared to cast Co-Cr alloys, wrought Co-Cr alloys that contain Ni, e.g., Co-Ni-Cr-Mo, have higher strength, however since Ni is potentially toxic, it is only used in those applications where this additional strength is required. The elastic modulus of Co-Cr alloys is higher than Ti or Ti alloys [30]. Compared to that of bone, the Co-Cr alloys have higher elastic modulus and greater density and stiffness [31], which leads to greater stress shielding than in the case of Ti and Ti alloys or Mg [32]. So Cobalt is a very potential material in this field.

Table 1 Negative impacts of the described metals

Material Name	Negative Impacts
1. Stainless Steel	1. Having stress shielding effects. [33] 2. High modulus of elasticity. [34] 3. Poor corrosion and wear resistance. [35] 4. The release of iron from stainless steel favors bacterial infections and could cause allergy, toxicity and other symptoms. [36]
2. Magnesium	1. Poor corrosion resistance due to the presence of Cl ion. [37, 38] 2. Hydrogen evolution due to rapid degradation. [39] 3. Lower elastic modulus. [40]
3. Copper	1. Poor resistance and repeated stress.[41] 2. Susceptibility to corrosion [42]
4.Zinc	1. There is a possible toxicity that should be taken into account [43]. 2. Corrosion of zinc implant should be estimated properly to skip medical hazard [43]. 3. Density and modulus of elasticity are slightly higher which may negatively influence the healing process due to non-uniform transfer of loading between implant and growing bone [44].
5. Aluminium	1.Bone Toxicity [45] 2.High propensity to participate in biological process [46] 3.Aluminium can cause premature cell death so it can cause bone apoptosis [47].
6. Cobalt	1. Expensive and quite hard to machine. [48] 2. Biological toxicity due to Co, Cr and Ni ions release.[49,50]

3. Numerical Modeling

3.1 Comparison of elastic modulus is shown in figure 1. Elastic modulus is the ratio of the force exerted upon a substance or body to the resultant deformation. Elastic modulus plays a vital role for bone implantation process. The metals of which elastic modulus are close to bone's elastic modulus are more preferred.

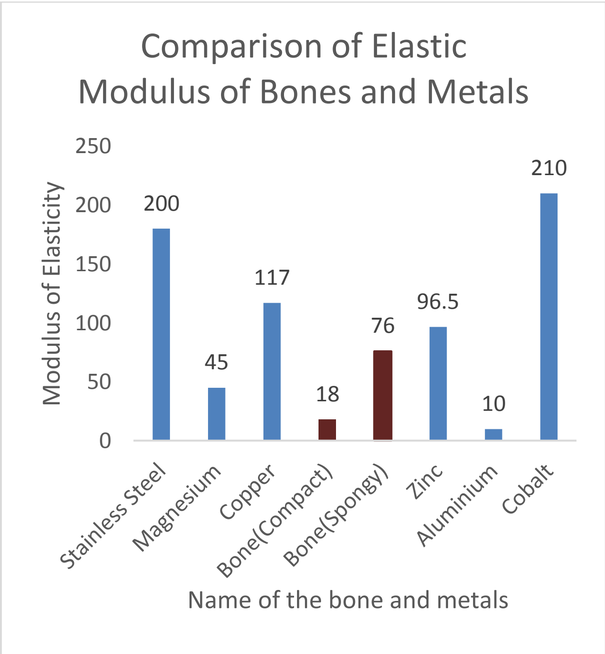

Fig.1 Elastic Modulus Comparison

3.2 The prices of above described metals are shown in figure 2. The price has been collected by International standard and the amount has been converted into BDT.

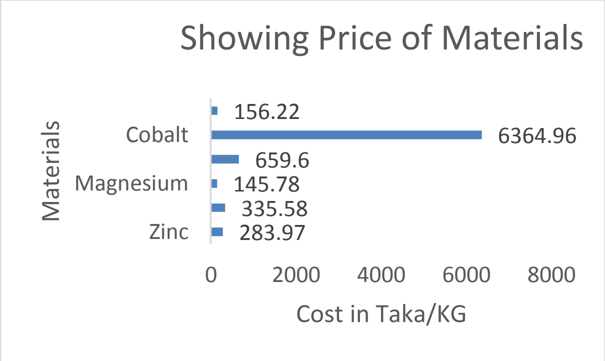

Fig.2 Price of materials described above for bone Treatment.

4. Conclusion: In this paper we have discussed about bone treating biomaterials specially metals which are very available in this country. These are used for various purposes. Implementation of these materials depends largely on the type of patient, conditions, symptoms, environment etc. Better treatment will result in better standard of life eradicating diseases while securing financial security. If Manufacturer companies adopt steps for researching these materials which are cost effective at the perspective of Bangladesh there may be a great scope

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