Bone Cement and Associated Failures with Total Hip Joint Replacement: A Review Study

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Abstract

Bone cement acts as a golden standard in the fixation procedurein orthopedics surgeries of the hip implant with the bone to induce stability and to increase implant longevity. Polymethyl methacrylate late bone cement is the most popularly employed enduring biomaterial in implant arthroplasty because it acts as an adhesive material that fills the space between the prosthetic joint and the surrounding bone tissue, thereby providing the patient with the necessary strength to carry out daily activities without assistance. It is the goal of this review to shed light on the present state of cementing techniques in total hip replacement surgery by describing the mechanical and physiological properties of bone cement as well as the cementing techniques used and the main challenges encountered when cementing implants associated with hip joint surgery are discussed. Aseptic loosening is believed to be one of the most popular reasons of failure of cemented hip implants. This impact is related to drawbacks in its mechanical integrity, cement mantle degradation, radiopacifier particles agglomeration, fatigue crack initiation, and mechanical loosening resulted from porosity. Therefore, a better understanding of these factors might induce an improved cement formulation to increase the survival rate of the cemented implant.

Keywords Bone cement, Polymethylmethacrylate, cementedimplants, total hip replacement.

1. Introduction

In recent years, the claim for hip arthroplasties has significantly raised to even more to 511,837 by 2030 (Saleh et. al., 2016). As a result, bone cement is employed in conjunction with total hip arthroplasty operations to fill the space between the bone and the implant, resulting in a tightly fitting area that avoids unwanted micromotion. Its main function depends on an adjacent mechanical interlock between the bone surface and the implants since it does not have any intrinsic adhesive properties (Vaishya et. al., 2013). Consequently, the excellent survival rates of total hip replacements and their stability rely on cementing techniques. Given that effective cementing gave the capacity for long-term efficiency without the need for revision, it was necessary to attain it. However, the rate of total hip arthroplasty patients has grown in recent years, mostly as a result of the prevalence of diabetes in the population. So the latest advancement in joint replacement technology allows for increased joint replacement lifespan (Breuschet.al., 2005). The strength of bone cement with hip stem implant is depending on introducing durable bonds between bone surface, bone cement, and implant without persuading bone necrosis (Bitsch et. al., 2007). In order to ensure the integrity of the implanted joint, bone cement is used to immobilize the implant. Furthermore, it serves as a trans-load carrying device to convey the weight and burden of the artificial implant to the bone around it. The bone cement works as a plaster, holding the prosthesis in place with strong adhesion and a durable interface, as well as preventing any displacement that may take place. As a result, the bone cement ensures that the total hip joint replacement is securely fixed in place (Breuschet.al., 2005). To ensure the strength of the interface between bone cement and bone, a

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strong interlock is desired during cement is pressurized at the surgery size. Bone cement might be affected in vivo environment that might compromise longevity at the bone- cement interface to degraded resulted from fatigue loading, creep, or fatigue crack (Waanders et. al., 2010).

The main component in the manufacture of bone cement is polymethy l methacry late (PMMA), which is available as a powder. The other component of bone cement is a liquid known as methylmethacrylate, and it was developed specifically for this purpose (MMA). A polymerization process between the powder and the liquid resulted as a result of the combination of these components, resulting in hard cement. During this polymerization process, there may be an emission of heat with a maximum heat range ranging from (40 to 47 degrees Celsius). While waiting for the polymerization process to end for the dough mixture to be created, heat energy is conserved and used more efficiently. Eventually, this dough would solidify, resulting in the production of firm cement (Breusch, 2001).

2. Mechanical properties

Since bone cement's primary role is to provide sufficient strength to transmit the stress from the prostheses to the bone and surrounding muscles, it is important to understand how it works. As a result, ensure that the patient has the capacity to supply himself with sufficient strength to maintain himself throughout his everyday activities by completing this task.The majority of total hip joint failures are caused by loosening of the bone cement component as a result of failure shear in the area of contact between the bone and the cement component. As a result, bone cement should possess properties that enable it to offer appropriate strength (Breusch, et.al., 2005; Breusch, 2001).Polymethyl methacrylate bone cement is a brittle material with a Young's modulus of around 2400 MPa, which is ten times lower than that of the surrounding spongy bone and one hundred times lower than that of the metal stem of the hip implant. Polymethyl methacrylate bone cement is used to repair fractures in the hip joint (Webb et. al., 2007). After many tests done on a patient wearing a prosthesis, the average mechanical properties indicated that the bone cement had a compressive strength of around 450 MPa (93 MPa). Furthermore, it was discovered that had a lower tension strength (35.3MPa) and a low modulus of elasticity (around 2 GPa), whereas the bone modulus of elasticity was approximately 20 GPa (Breusch, et.al., 2005). Furthermore, the acrylic bone cement has a shear strength of around 40 MPa, whereas bone has a shear strength of between 3 and 10 MPa (Amirfeyz et. al., 2009).It was discovered that the bone cement has viscoelastic characteristics in addition to its elastic characteristics. Changes in the mechanical properties of the bone cement will be caused by the environmental factors present during the placement of the bone cement. Changes in the water in the environment around the bone cement occurred because of the presence of water in the environment, which led to the absorption of water. This, in turn, caused changes in the cement's physical properties. As a result, while creating bone cement, it is significant to consider the viscoelastic characteristics of the material so that it can adapt to the changing nature of the bodily environment (Eveleigh, 2001).

One of the viscoelastic characteristics is creep, which may be represented as variations in strain over time while the tension remains constant in a given situation. The creep is primarily influenced by the surroundings of the bone cement, with the creep increasing in proportion to the strain applied. In addition, when a compression or shear force is applied, the bone cement will creep, although at a slower pace than when a tension pressure is applied, as seen in Figure 1. Furthermore, the creep rate will be impacted by the passage of time, such that as the age of the bone cement increases, the creep rate will decrease. Additionally, when the cement is tested under stress, the creep might cause the direction of the cement to shift. This alteration occurs as a result of the formation of bands on the cement's outer surface, which caused the cement to move owing to creep. A high porosity bone cement material will also exhibit more creep deformation than a less porous bone cement material. As a result, creep is seen as a mechanical problem that has the potential to slowly degrade bone cement (Eveleigh, 2001; Lee, 2002). Strain relaxation, which is a

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viscoelastic property that occurs in addition to stress relaxation and indicates a change in stress over time while the deformation induced by strain stays constant, is another characteristic of viscoelasticity. The tension release will take place at the polymer of the bone cement, not the bone itself. Additionally, the stress-relaxing effect is caused by the same mechanisms that cause the creep. For instance, time, temperature, and habitat are all important considerations (Lee, 2002).After then, there is the issue of fatigue, which is caused by repetitive exposure to a cyclic load that causes the material to fail. The majority of metal used in implants has an endurance limit, which means it has the capacity to maintain its original shape and will not fail once a certain degree of stress has been reached. However, because the polymer does not have that limit, it will fail once a sufficient number of load cycles have been applied to it (Breusch, et.al., 2005; Lewis, 1999).

Additionally, another characteristic of bone cement, such as porosity, may have an impact on the strength of the cement. It is thought to be the gap between cement molecules that has an effect on the mechanical strength of bone cement and has resulted in the implant becoming loose. This porosity is caused by air trapped between the PMMA molecules when they are wet from the monomer liquid or during the form mixing process. Additionally, when the bone cement mixture is transferred from the intestine to the application device, it is possible that air will become trapped between the cement molecules. Furthermore, hand mixing the component of bone cement promotes the cement's porousness, thus the other approach utilized helps to mitigate this impact. Vacuum mixing, pressured cement, and centrifugation, for example, assist to minimize the amount of air trapped between cement molecules (Lewis, 1999). Viscosity is another characteristic of bone cement. It's used to measure the thickness of a fluid by showing how difficult it is to flow. During the early phases of the polymerization process, the solution's viscosity would be low. To reach the bone location, the dough needs the help of the cement. However, with time, the viscosity of the bone cement grew to the point where it can survive the body's environment. When bone cement is used with an implant, one of the problems it faces is back bleeding pressure, which reduces the cement's stability and makes it weaker (Kuehn et. al., 2005).

3. Bone cement phases

Because bone cement is made up of two major ingredients: powdered PMMA and liquid monomer MMA, a reaction between these molecules occurred (Ling et. al., 2010).When monomer molecules are joined with polymer molecules, the exothermic polymerization process will release heat energy from the monomer molecules (Breusch, et.al., 2005; Todd, 2010). Along with the mixture, they will add a benzoyl peroxide (BPO), which will function as an initiator to ensure that the polymerization occurs at ambient temperature. It is also planned to incorporate additional minerals, such as zirconium dioxide ($ZrO2$), into the mixture, which is not expected to participate in the polymerization reaction (Kühn, 2005).This substance, on the other hand, is introduced in order to detect any failure or loosening of the implant (Todd, 2010). As a result, the polymerization process takes place in steps in order to generate bone cement, with the mixing phase being the first of these phases to occur. When the polymer has completely dissolved in the monomer-containing liquid, the monomer phase is set to begin. This technique was repeated until a homogeneous dough that was reasonably liquid and had reduced viscosity was achieved. The initiator will also be in charge of stimulating the interaction between the components during this phase, as previously stated (Hosseinzadeh et. al.,2013; Ong et. al., 2013). Second, following the mixing phase, there was a waiting phase, which was followed by another mixing phase. This step will include leaving the bone cement dough alone for several minutes to allow the polymerization chains to lengthen, resulting in a rise in the viscosity of the bone cement dough during this time. Additionally, the dough is checked by putting on the surgeon's gloves to ensure that it does not get sticky. The amount of time it takes from the start of mixing until the bone cement dough is no longer sticky in the surgeon's gloves, which is generally between two and three minutes in most cases. As a result, this phase will come to an end as soon as the bone cement dough no longer becomes sticky, allowing the third phase to begin. Third, this phase is referred to as the working phase since it is during this period that the polymerization between the components continues.As a result, heat from the polymerization was released, causing the cement to expand while the viscosity was still growing. This phase will come to an end when the dough can no longer be kneaded by hand effectively. The surgeon should implant the prostheses prior to the completion of this phase. Typically, this phase takes between five and eight minutes to complete before the following step may be initiated (Hosseinzadeh et. al., 2013Ong et. al., 2013). Finally, the fourth step is referred to as the setting phase, during which the cement hardens and becomes durable. When the temperature reaches its maximum on that level, it will begin to gradually fall, and the polymerization process will come to a stop at this point. When the bone cement's temperature reached the same level as the body's temperature, it would shrink, and this would take between eight and ten minutes on average. However, variables such as temperature, humidity, cement type, and mixing technique may have an impact on these stages. As a result, increasing the temperature causes the reaction to occur more quickly, resulting in a shorter time required for the dough and setting phases. The amount of time that would be reduced would be five percent for every degree centigrade that would be dropped. Furthermore, increasing humidity would have an effect on the setting process by making it more time consuming. Otherwise, if it dropped, it would cause the phase to be postponed.Aside from that, rushing the mixing method would be undesirable since it may result in the bone cement becoming more porous and, thus, weaker. In addition, the percentage ratio of powder to liquid utilized will have an effect on the phase separation. When the powder is twice the volume of the liquid, the desired ratio is achieved. In the event that the liquid was used in excess of the needed ratio, or the powder was used insufficiently, this will have an effect on the setting phase by increasing the time required. The setting time will be shorter if the amount of liquid used is smaller, or if the powder to liquid ratio is higher than in the preceding example (Hosseinzadeh et. al., 2013;Ong et. al., 2013).

4. The mixing procedures used in the production of bone cement

The first time bone cement was used in a hip joint was in the early phases of the process, when it was mixed by hand. Because of this, the components were combined in an open bowl or by kneading them together in a bag for mixing purposes. This technique, on the other hand, encourages the formation of more porous bone cement since it uses an open bowl for mixing, which aids in the trapping of air inside the mixture. Hand mixing is expected to provide a porosity ratio of around 7 percent or higher, depending on the method used (Macaulay et. al. 2002). Additionally, utilizing an open bowl for mixing can release toxic fumes, which can raise concerns about the health and safety of the employees because of the detrimental effects on their health. In order to control the flow of toxic fumes, the construction company is employing a paddle that is connected to the wall suction in order to seal the mixing bowl, which reduces the porousness of the cement and further seals the toxic fumes, as well as reducing the amount of cement that is exposed to the air (Macaulay et. al. 2002; Lindén, 1991).In addition, they employed vibration to mix the cement, however this did not result in the desired cement mixture being produced (Lindén, 1991). Therefore, a different method such as centrifugation has been employed instead. After being mixed by hand, the cement components are subjected to centrifuge in order to remove any air pockets that may have formed in the cement mixture during mixing. This process necessitated cooling the liquid before combining it with the powder, after which it would be mixed with the powder.The cement will be spun in centrifugation at a speed of 2300 to 4000 rpm for a duration of one to three minutes at a speed of 2300 to 4000 rpm. After that, the cement mixture will be drawn out using a syringe and placed into the centrifuge machine, which will revolve at a high speed for a short length of time. The reduction in cement porosity by about 1 percent achieved through this approach resulted in an increase in the mechanical strength of the bone cement (Lindén, 1991; Alkire et. al., 1987; Mau et. al., 2004).It has recently been discovered that a new technology called as vacuum mixing may be employed in the mixing of bone cement. As a result of using this approach, the bone cement was mixed in a confined vacuum environment, which prevented porosity from forming and any fumes from being released. In a cartridge or a closed bowel linked to a wall suction, all of the materials for bone cement are combined to prevent any air from entering the mixture while it is being mixed.To make up for the loss of tensile strength due to bone cement movement, this approach helps increase the tensile strength of the bone cement and preserve the life of the bone cement (Lindén, 1991; Alkire et. al., 1987; Mau et. al., 2004).

5. Application Methods

The next stage in the hip replacement surgery is to apply the bone cement to the femur canal, once the bone has been prepared and the bone cement has been mixed. At the commencement of the total hip arthroplasty procedure, the hand-packing technique was utilized to provide pressure to the joint (Klein et. al., 2004).A finger was used to pack bone cement into the canal after it had been formed, and the bone cement was pressed into the proximal end of the femur after it had been pressed into the bone canal. It is anticipated that the finger will pressurize the bone cement when it enters the femur canal and travels to the distal end of the femur canal (Klein et. al., 2004). In addition, the syringe injection technique was employed to administer bone cement, in which the cement was forced into the medullary canal with the help of the syringe. Nevertheless, gun pressurization, which enhances interlock between the bone and the implant, is the most successful method available today. The surgeon can drive the cement dough into the medullary canal with the help of the gun pressurization, which guarantees that the cement reaches the distal end of the medullary canal. This increases the interlock between the cancellous bone and the implant stem, which is beneficial (Klein et. al., 2004).

The preparation of the bone prior to the introduction of the bone cement and the implant is a component that contributes to the lifespan of total hip replacement. The more cleanly the bone is, the more efficient the adhesion between the implant and the bone with the cement may be achieved (Majkowski et. al., 1993). Consequently, the bone preparation process starts with reaming the femur and acetabulum bone, which involves the removal of a portion of the cancellous bone while leaving the dense portion of the bone that is closed to the cortex. This is accomplished by the use of a tapered reamer, which removes the majority of the cancellous bone. Keeping a portion of the cancellous bone, on the other hand, is critical for creating a strong connection between the cement and the femoral bone. After the femoral canal has reached the length specified, the reaming operation is continued to widen the channel. When a line on the reamer line up with the stem of the femoral reamer, the reamer will go straight to the line, instead of skirting around it (Majkowski et. al., 1993). Another instrument, known as bone Pulsatile lavage, is utilized to remove the whole unwanted cancellous bone, blood clot, and marrow fat that has been removed during the bony bed reaming of the femoral canal after the bony bed reaming has been completed. This instrument allows for a considerable improvement in bone cement arthroplasty by improving the permeability between bone and cement and lowering the pulmonary physiological problem, both of which were previously unattainable (Majkowski et. al., 1993; Krause et. al., 1982; Maggs et. al., 2017). A femoral brush is then used to remove any material that has been discovered for producing a clean bone bed. After the bone has been thoroughly cleansed, the following stage is to provide a white bone that is clean and dry. As a result, they employed a femoral absorber in order to achieve their objective. The utilization of an operating room suction that is connected to the distal end of the femur canal absorber is an example of this. Additionally, the surgeon discovered that the dryer the bone was, the greater the improvement in the penetration between the bone and the cement was. The acetabulum is also subjected to the same treatment, with the loose cancellous bone being removed and the thick section being retained, as well as any debris being cleaned away. Additionally, drying the acetabulum should be performed after cleaning, as it is difficult to do this due to the fact that no canal can reduce bleeding. A sponge, on the other hand, is used to absorb the bleeding and facilitate the drying of the bone. Following this procedure, the surgeon will drill holes into the acetabulum bone for establishing a long-term joint fixation. Following the completion of the cleaning and drying procedures, the bone cement mixture can be inserted into the femoral canal in order to complete the hip joint replacement procedure (Majkowski et. al., 1993).In addition, based on hip anatomy, implant size, and design, a minimum cement mantle thickness of about 2–3 mm is necessary to provide a lasting contact between cement and bone and to prevent any loosening or osteolysis from occurring (Breusch, 2001).

6. Antibiotic bone cement

Infection at the implant surgical site is considered one of the crucial reasons for implant failure. Thus, the adding of antibiotics to bone cement with a specific amount to prevent multi-resistant bacteria had been reduced the infections rate (Alt et. al., 2004).

The formation of biofilm resulted from bacterial strains as an outcome of adherence between bone cement biomaterials and bacteria (Bistolfi et. al., 2011).Antibiotics are representing asa drug that preventspathogens predominantly from skin and skin antisepsisfor instance Staphylococcus aureus and Staphylococcus epidermidis. By loading itinto the bone cement makes it a local drug delivery system (Kühn et. al., 2016; Dobson et. al., 2020; Cara et. al., 2020). This technique permits of sustained release of antibiotics at the surgical position after closing the wound (Ruzaimi et. al., 2006). The mechanisms of antibiotic release from bone cement at the surgical site either through pores in the surface of bone cement or through diffusion (Baker et. al., 1988).Nevertheless, its usage at the surgical site has raised some controversial points, such as provoking antibiotic resistance after extended exposure time, toxicity, and mechanical loosening by affecting porosity (Martínez- Moreno et. al., 2017). However, the required dose of antibiotic depends on its function either as a treatment or as prophylaxis. Where it found that the suggested drug levels as a therapeutic can be achieved at 3.6 g of antibiotic to 40 g of bone cement. On the other hand, if it is meant to use as prophylaxis, then a low dose of about 1 g of antibiotic per 40 g of cement will be adequate (Martínez- Moreno et. al., 2017; Anagnostakos, 2017).Pennerand his co-authorselucidate that merging two antibiotics such as tobramycin andvancomycin in bone cement has been enhancing elution in vitro while the mechanism is unidentified (Penner et. al., 1996). Moreover, another study done by Chen and co-worker showed that after formulation a 4 g ofpolymethylmethacrylate bone cement with 0.3 g gentamicin improve the anti-microbial effects byenhancing the elution of antibiotics without affecting the mechanical strength of bone cement (Chen et. al., 2021).

7. Associate failuresof bone cement in total hip arthroplasty

In the United States, the most common reasonsforfailure in the total hip joint replacementwerethe implant instability and mechanical loosening which then required revision surgery (Bozic et. al., 2009).Therefore, bone cement plays a role in the failure of the implant. One of the factors that influenced the quality of bone cement is the mixing procedure. It has been noticed that the insufficient process of mixing can generate a porous in the cement which is overtime led to initiate a crack in the bone cement. Since these porous actsweaken the cement, which is generating from mixing the cement in the open space that allows air to entrap with mixing. Also, these pores can be initiated from the transfer of bone cement to the injection syringe. Therefore, reducing the porosity of bone cement can increase the fatigue life of the implant(Lewis, 1999). In addition, the increase in the temperature results from the polymerization process, if the mixture is applied to the bone can lead to damage of the bone tissues. This can lead to failure of the implant fixation(Todd, 2010). Also, if there are any debris results from removing the cancellous bone or from the soft tissue can make the cement crack with the time that will end with stem loss(Majkowski et. al., 1993).Another issue faced the cemented orthopedics surgeries is bone cement implantation syndrome (BCIS), it can be mild to cause hypotension or severe to cause fatal cardiac diseases. The etiology behind BCIS is not clear but one of the hypotheses suggested that circulating MMA monomers possibly will lead to vasodilation in vivo researches to be the main reasons for the pulmonary and cardiovascular diseases perceived in BCIS (Hines et. al., 2018). Correspondingly, it has been described that bone cement comprising barium sulfate and zirconium oxide that might tolerance increase the risk of osteolysis with particles size less than (7µm) due to stimulation of mononuclear phagocytes and bone resorption in vitro and in vivo as compared with bone cement without addition (Ingham et. al., 2000; Agarwal, 2004).

Also, the fatigue failure of bone cement resulted from progressive micro-crack instigation within the cemented implant resulted in a drawback in its mechanical integrity (Sinnett-Jones et. al., 2005).The factors that raised the presence of fatigue cracks initiated from bone cement microstructure which are pre-polymerized beads, voids, and radiopacifier particles resulted from particle agglomeration (Browne et. al., 2018). Besides, any movement at the bone–cement interface is found to be a major cause foraseptic loosening, and it can be diminished by a stronger interlock between bone tissue and bone cement (Amirfeyz et. al., 2009).It has been shown that by treated the implants with precoating and porous coating might improve the strength of the interface (Gardiner et. al., 1994). Researchers from Swedish demonstrated that the aseptic loosening induced failures in 60% of total hip arthroplasty in the latter 26 years (Karrholm et. al., 2006). Moreover, recent researchers have elucidated that the addition of antibiotics to bone cement might affect its mechanical strength. While other studies showed no significant variance in the failure rates between prosthetic joint and surrounding bone tissue, with or without adding gentamicin (Espehaug et. al., 2002). On the other side, Jasty and co-authors suggested some points that might increase the lifetime survival rate of hip fixation. For example, control the properties of bone cement mantle thickness, reducing its porosity, and interlock the interface between cement and boneto reduce the complication of revision surgery (Jasty et. al., 1991).

8. Cementless total hip arthroplasty

There is another approach that has been utilized for hip replacement that does not rely on the presence of bone cement, and this operation is referred to as cementless fixation. This method depends mostly on bone development, in conjunction with the prosthetic device, to provide the necessary stability to the patient.The usage of the cementless technique rise a benefit that cement bone faced which is the hazard ofembolization and it helped in reducing cardiopulmonary stress (Jämsen et. al., 2014).Because the prosthesis has pores coated on it that allow bone to grow, this procedure is carried out by enabling bone to grow in the prosthetic while the prosthetic is in place. So the titanium femoral stem, which is porous-coated and encourages bone growth, was used to provide the requisite stability. However, this technique took longer to achieve the ideal stability since it required more bone growth. Other types of materials, such as hydroxyapatite, are sometimes used in conjunction with the prostheses to function as a bone growth stimulant and promote bone growth (Vidalain, 2011). Furthermore, this form of fixation has the same requirements for bone preparation as the previous type, which is a clean and dry bone in order to produce a secure attachment. The ratio of bone growth in conjunction with the prosthesis was about (1-2) mm, and this surgery necessitated the use of fixation aids such as screws or begs until the bone developed in conjunction with the implant. In comparison to the cemented approach, the uncemented procedure necessitated a longer period of time until bone development occurred, which was typically three months. In contrast, the cemented technique requires 10 minutes after adding the cement to the hip joint in order to give sufficient strength. The cementless approach, on the other

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hand, offers a distinct advantage over the cemented technique in that it provides more long-term prosthetic life than the cemented implant. Furthermore, there is no concern about the cemented components failing due to the fact that the fixation is dependent on the development of the bone.While the majority of the problems associated with the cementing process are due to a fracture in one of its components, which resulted in a loss of the prosthetic implants, Furthermore, the cementless approach is preferred for patients who are comparatively younger in age, whereas the cement-based process is employed with elderly persons who are older than seventy years (Abdulkarim et. al., 2013). Another research conducted by Phedy and co-authors comparing cement and cementless implants revealed that implant longevity was shown to be greater in cemented fixation than in other kinds of fixation, including screw fixation (Phedyet. Al., 2017). Furthermore, the cost of the implant when using the uncemented approach is higher than the cost of the implant when using the cemented technique (Yates et. al., 2006).

Conclusion

Overall, bone cement is considered one of the essential parts in the field of joint arthroplasty surgery. Since it acts as a milestone in fixation of the hip implant with the patient's bone to produce immobilization. Besides, the hip replacement procedure successes depend on the materials of bone cement that have been used and the surgeon's efficiency in handling the procedure. Also, in the case of cemented technique, the success of this type of arthroplasty depends on the devices that have been utilized either in the mixing or in the cementing application. Since these techniques affect the enhancement of the cementing property by reducing porosity. Also, the implant success depends on the bone preparation by providing a clean bony bed to create a strong bond between bone and the implant. Also, the problems related to mechanical characteristics of bone cement can be improved by better understanding of these effects on aseptic loosening, fatigue crack initiation, and micro structure of bone cement to come up with a better cement formulation to increase the survival rate of orthopedics surgery and reduced the need for hip revisions.

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