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Polymethylmethacrylate Bone Cement

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While the origins of polymethylmethacrylate (PMMA) bone cement can be traced as far back as the 19th century, the earliest applications in medicine were in the 1930s in the field of dentistry. In orthopedics, Herschell and Judet are credited with some of the early documented applications of PMMA in 1945 and 1950. Early forms of acrylic bone cement were used as femoral head prostheses.[1] In 1953, Haboush used PMMA, in a similar fashion as seen today, as a grout to enhance fixation of implants. However, it is Charnley, in the early 1970s, who is often credited with pioneering the current usages of PMMA during cemented total hip arthroplasty. Bone cement, also known as acrylic acid for its very recognizable smell, is used not as an adhesive or glue but rather as a grout relying on fixation by interlocking fit between surfaces, bone-to-cement and cement-to-metal prosthesis.

The PMMA used in modern orthopedic surgery is a polymer that is often stored in 2 separate states, as both a liquid and powder form. The liquid typically contains a methylmethacrylate (MMA) monomer, hydroquinone, and dimethyl para-toluidine. The hydroquinone is a stabilizer that inhibits premature polymerization of the MMA from heat or light prior to mixing with the powder. The dimethyl para-toluidine is used to accelerate the polymerization process once the powder is added. The powder portion of PMMA, usually doubling the amount of the liquid, contains polymerized PMMA mixed with comonomers of styrene, methyl acrylate, or butyl methacrylate, which adds to the strength of the final product. To visualize the final product on radiographs, a radiopaque material such as barium sulfate or zirconia is added to the powder solution. Finally, a dye like chlorophyll is added to distinguish its color from that of bone. The powder and liquid solutions are mixed to form the final PMMA product ready for use during an operation.

Polymerization Process

Bone cement is packaged in its powder and liquid forms intended to be mixed during the operation. Mixing the separated components initiates the polymerization process. This process would normally take hours and would be unreasonably long during a surgical procedure. However, the process is accelerated by the activators added to the solution. Pure MMA has a very low viscosity and if introduced prior to polymerization, could seep into the blood system and possibly cause cardiorespiratory distress.[2] Mixing the liquid MMA and powder PMMA increases the viscosity during polymerization and allows the final product to remain where it is placed. The polymerization process begins by creating benzoyl free radicals, which break the original carbon-to-carbon double bonds of the MMA. That initiates a free radical chain propagation that results in new carbon-to-carbon single-bond long-chain polymers.

The polymerization process can be observed by the members of the operative team in 4 stages: the mixing period, waiting period, working period, and hardening period. The mixing period is characterized by combining the liquid and powder substrates. Even at this early stage, the polymerization process has initiated as the room temperature and ambient air are catalysts for the free radical chain reaction.

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