The Role of CarboJet CO_2 Bone Preparation in the Reduction of Aseptic Loosening in Knee Arthroplasty

Introduction: Recent evidence from a large multicenter study shows that aseptic loosening has become the single largest cause of failure of modern primary knee arthroplasties requiring revision. Earlier studies, conducted in the 1990s, had shown polyethylene wear to be the leading cause of failure. The more current study found that 28.0% of all knee failures were due to aseptic loosening, comprising the single most common failure mode. In the case of unicompartmental knees, 60.6% of failures were due to aseptic loosening. A significant portion of the aseptic loosening failures were early failures, with 32.9% of these failures classified as never successful, suggesting failure of initial fixation.[1]

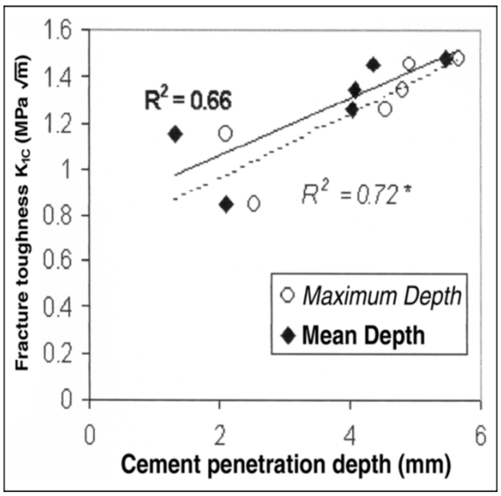

Fig. 1. Graph showing positive correlation between cement penetration depth and cement mantle toughness.[2]

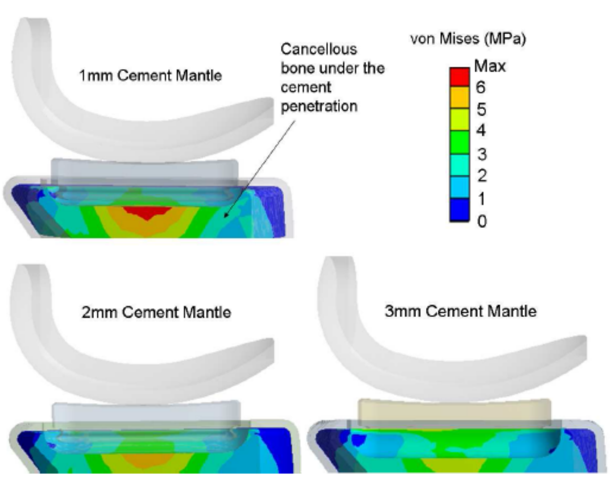

Fig. 2. 3D finite element analysis shows interface stresses decrease as cement penetration depth increases.[3]

These findings suggest that meticulous attention to cement technique and proper preparation of the bone bed prior to cementation may improve implant longevity and quality outcomes. There is also considerable evidence suggesting that increased cement penetration depth into the bone bed improves cement mantle toughness and reduces cement-bone interface stresses (Figs. 1 & 2)[2,3]. Of particular note, a recent tibial component retrieval study showed that there is a time dependent resorption of interlocking trabecular bone away from the cement mantle. This progressive loss of cement interdigitation with time in service suggests that it is important to ensure maximum cement penetration and interdigitation at implantation (Fig. 3).[4]

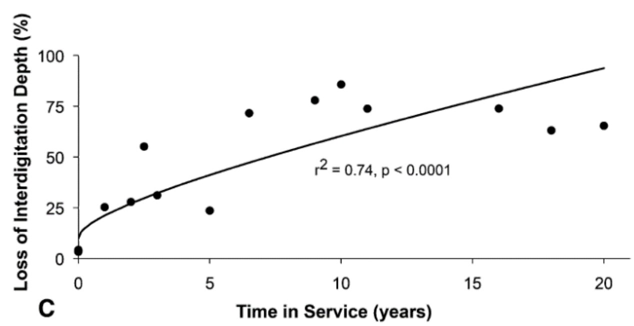

Fig. 3. Graph showing time dependent loss of cement interdigitation measured in tibial retrieval specimens.[4]

Role of CarboJet System: The CarboJet system (Fig. 4) uses pressurized, filtered medical-grade carbon dioxide (CO_2) gas to remove fatty marrow elements, saline and blood from the bone bed to provide for a cleaner, drier cement-bone interface and increased cement penetration depth. Studies conducted with CarboJet show that it results in a 26% to 35% increase in trabecular cement penetration depth when compared to the use of pulsatile saline lavage alone.[5,6]

CarboJet has also been shown to increase cement-bone interface strength in an experimental model. Cadaveric radii specimens were prepared using either syringe saline lavage or CarboJet, injected with bone cement and then subjected to cement plug push out testing on an Instron machine. Push out force values were significantly higher at 581 Newtons for the CarboJet specimens versus 366 Newtons for the saline specimens (a 58% increase).[7]

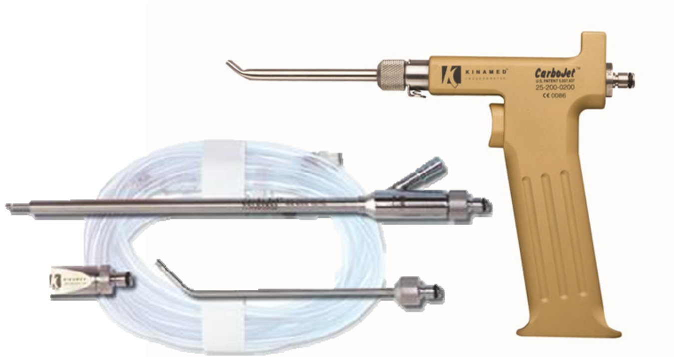

Fig. 4 The CarboJet system consists of a handpiece and various nozzles and connects to medical grade CO_2 via a tube set containing a sub-micron particle filter.

In addition to the cement penetration studies on CarboJet, users observe a much improved cement mantle on post-op radiographs as compared to their previous experience using pulsatile saline lavage. In addition to deeper cement penetration, an overall higher quality cement mantle is noted with fewer radiolucent lines (Fig. 5).

<u>Conclusions:</u> Given that aseptic loosening is recognized as the most frequent cause of primary knee implant failure, and that failures of primary knees involve significant morbidity for patients and expense for the healthcare system, careful attention to cementation techniques should be observed. Projected hospital costs for revision TKA procedures in the Medicare population may exceed $2 billion per year by 2030.[8] The CarboJet system offers a low cost means of effectively cleaning and drying the bone bed that results in greater cement penetration depth and increased cement-bone interface strength. The system is easy to use and typically does not add any procedure time as cleaning can be accomplished during cement mixing.

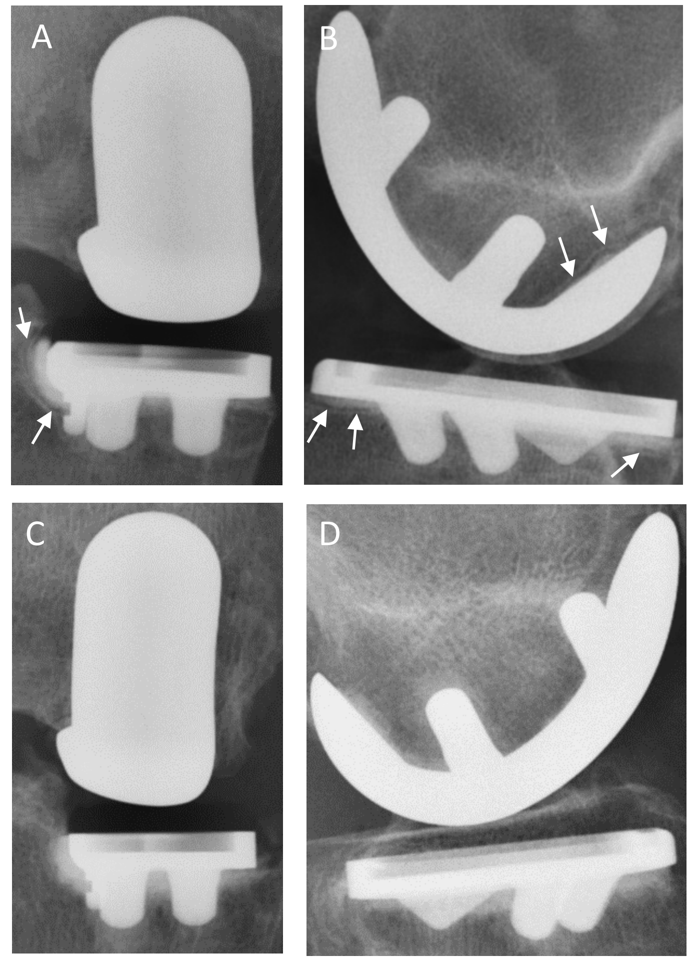

Fig. 5. (A & B) Bone bed cleaned with pulsatile saline lavage only, arrows indicate radiolucent lines. (C & D) Bone bed cleaned with syringe saline lavage and CarboJet. *Radiographs courtesy of Dennis McGee, MD.*

1. Schroer, Berend, Lombardi, Barnes, Bolognesi, Berend, Ritter, Nunley (2013) Why Are Total Knees Failing Today? Etiology of Total Knee Revision in 2010 and 2011. J of Arth 116-9.
2. Graham et al (2003) Effect of Bone Porosity on the Mechanical Integrity of the Bone-Cement Interface. J Bone Joint Surg Am. 85:1901-1908.
3. Thompson, et al (2010) The Importance of a Good Cement Mantle with an All-Poly Inlay UKA. ORS. New Orleans, USA.
4. Miller et al (2014) Loss of Cement-bone Interlock in Retrieved Tibial Components from Total Knee Arthroplasties. Clin Orthop Relat Res. 472(1): 304–313.
5. Goldstein (2007) Improvement of cement mantle thickness with pressurized carbon dioxide lavage. ISTA. Paris, France.
6. Woodgate (2008) A radiological comparison of cement mantle thickness around TKA with or without the use of pressurized carbon dioxide lavage. Australian Orthopaedic Association.
7. Stanley (2010) Bone-Cement interface strength in distal radii using two medullary canal preparation techniques. Hand Surg 15:95.
8. Lavernia et al (2006) The Increasing Financial Burden of Knee Revision Surgery in the United States. Clin Orthop Relat Res. 446: 221–226.

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