



■ EDITORIAL

The ‘French paradox’ may not be a paradox after all – but for what reason?

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Although the popularity of cementless femoral stem fixation continues to rise, cemented femoral fixation still serves as the benchmark, with the risk of mechanical failure of fixation having shown to be negligible in the first decade,^{1,2} and periprosthetic fracture having been identified as the main cause for revision in the second decade after implantation.³ There is universal agreement that implementation of a modern cementing technique is a condition *sine qua non*, and the quality of cementing technique and the establishment of optimal cement interdigitation and non-deficient cement mantle have been identified to be the most predictive factors for favourable long-term outcome.^{4,5}

Although various types of cemented stems are in clinical use, with favourable and predictable outcome reported both in small series^{2,6,7} and in national registries,^{1,5,8} there is still controversy regarding the best and most forgiving stem design (shape and surface) and the optimal cement mantle thickness.⁹⁻¹¹

For the former, attempts have been made to categorize stem designs mechanically into shape-closed *versus* force-closed.¹² Advocates of each philosophy have claimed their concept to be advantageous over the other, however, the clinical literature has shown successful long-term results for both.¹² Interestingly, it has been proposed that shape-closed stems show superior results when surface finish is roughened to a certain amount to enhance bonding between the stem and cement.¹² However, in the literature both the so-called shape-closed¹³⁻¹⁵ and force-closed¹⁶ designs with superior long-term survival have smoother stem surface finish. Thus, importantly, clinical experience and the reported outcomes seem to suggest that this is not such a ‘black and white’ scenario.¹⁷

For the latter, i.e. the property of the cement mantle, the so-called “French Paradox”, which was reported more than a decade ago, has received considerable attention.⁹ This “paradox” was described as excellent long-term outcomes with the Kerboull (CMK) stem in the

presence of a radiologically evident “thin” cement mantle, even though thin cement mantles had been shown to be prone to failure with rough surface stem designs.^{13,18,19}

Numata et al²⁰ have recently re-visited the “French paradox”, and examined the subsidence of CMK stems implanted with either > 2 mm or < 2 mm cement mantle using radiostereometric analysis (RSA) as the outcome measure in a non-cadaveric model (without cancellous bone) of plastic femurs. The tests were carried out at 37°C and mimicked clinical loading conditions incorporating time for cement stress relaxation and allowing for cement creep. While the experiment has been very well designed and excellently conducted, the model and interpretation of the findings merit further attention.

Importantly, their model, unlike those using cadaveric femurs such as Burgo et al,²¹ did not include cancellous bone for cement interdigitation, and hence misses one fundamental aspect of cement mantle long-term function, i.e. the composite cement mantle. Thus, by default a “revision” scenario of a non-interdigitated cement mantle has been studied by Numata et al.²⁰ However, cement interdigitation is of paramount importance for long-term fixation both in primary and revision THA²² – hence the rationale for using impaction grafting!

Somewhat ironically, but in our view fortunately, in the clinical *in vivo* scenario of surgical femoral canal preparation, even with aggressive line to line broaching, a peripheral layer of strong cancellous bone will remain and not all cancellous bone can be removed. Effectively this means, that the true, i.e., composite cement mantle, even in line-to-line cemented stems *in vivo*, is actually thicker than anticipated and seldom less than 2 mm in thickness, even if aimed to be “thin”.¹¹ The fact that the true cement mantle is thicker (i.e. > 2 mm) in most Gruen zones than suggested to be the case on standard anteroposterior (AP) radiographs has been shown in cadaveric analyses of human

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retrievals, which allowed for a three-dimensional cement mantle analysis.^{10,23} Scott et al¹⁰ elegantly demonstrated that even radiologically perceived “thin” cement mantles on AP films are usually thicker on lateral radiographs, particularly proximally, even in “distally press-fitted” stems.

Clinically, a “thin” cement mantle or complete stem to cortex contact scenario may not be achievable after all,¹² hence leading to the conclusion that the majority of the stem, at least proximally, is not surrounded by a thin cement mantle.^{10,23} These circumstances therefore raise doubt whether a “French paradox” exists after all, or is actually a myth. Clinical experience has shown, however, that a Kerboull type design¹⁴ may tolerate thinner cement mantles compared with other stem designs, which are reliant on degree of stem subsidence – forced-closed “sinker” designs – such as the polished double taper Exeter stem.²

The modes of fixation, and also ultimately failure, appear to be far more complex¹² and the ideal cement thickness around polished stems remains unknown.²⁴

Regardless of the stem design philosophy, it should be re-emphasized that while an incomplete and therefore deficient cement mantle would not necessarily jeopardize mechanical fixation, it will, however, allow access of (polyethylene or poly(methyl methacrylate) (PMMA)) wear particles to access the bone-cement interface,²⁵ which might be the precursor of particle-induced osteolysis and failure in the long term.^{26,27} It is for this reason that a cement mantle might be “thin” (i.e. < 2 mm) in some areas, but it should not be deficient.

Furthermore, cement mantle fracture/failure is a time and repetitive loading dependent fatigue mechanism and a “thin” cement mantle is more prone to such fatigue failure over time. Correctly, Numata et al²⁰ emphasized the limitations of their study design of applying cyclical loading (1 Hz, maximum 3000 N) one million times, estimated to be equivalent to one year of walking. However, even a surgically poorly manufactured cement mantle will not fail in the short term.

We therefore feel that the correct conclusion in the relation to the “French paradox” is that the Kerboull stem functions well, not because of, but despite a “thin” cement mantle in some areas. Furthermore, the perceived “thin” cement mantle may not be “thin” after all. While mechanically a thin and partially deficient cement mantle may suffice, biologically, in the long term, this may prove detrimental.

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Conflict of Interest Statement

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