Summary

In this chapter, clinical and experimental evidence is reviewed with respect to implant survival in relation to cement mantle thickness. The so-called French paradox of excellent survival with thin cement mantles is discussed. Cement mantles perceived as «thin» may in fact by thicker than expected.

Introduction

It has become generally accepted that the cement surrounding a proximal femoral implant should be not less than 2 mm thick and that it should be complete i.e. without any ‘windows’ in the mantle. The widely used Barrack grading for cementing included no comment on the thickness of the cement mantle on its introduction in 1992 [1]. The following year the ‘A’ grade was qualified by the addition of the minimal thickness of 2 mm to its requirements [7]. Certain considerations arise:

- If a rectangular section tapered implant is used, distally the cement is unlikely to be uniform in thickness. At the corners of the prosthesis in all probability the cement will be thin at a site exposed to the increased torsional forces. Is this desirable? Amongst the contributing authors there is no consensus. On one hand it is felt that a rectangular cross section to the stem dissipates the torsional moment within cement mantle at the bone cement interface. On the other hand a stem rounded in the diaphyseal region would transfer torsional load in the metaphyseal region and risk cement cracking. This latter concern has been specifically addressed in one stem reported here by intentionally retaining of the femoral neck [2].

- If the medullary canal is narrow in the presence of thick cortices either extensive reaming of cortical bone or the use of a very thin stem would be necessary. Are either desirable? Two recent publications have questioned whether the 2 mm minimum thickness is the only way to successfully stabilize a proximal femoral component.

The Evidence

The credit for questioning this approach to cement handling lies with the observations of Marcel Kerboull. In 1971, with only a 2 year experience using the original Charnley stem, he noted a high rate (24%) of debonding associated with a longitudinal superomedial crack in the cement mantle which appeared to be associated with subsequent stem subsidence. Surprisingly, this problem was not observed in the dysplastic femur where the tightly fitted straight stem left room for only a thin cement layer. From this experience, changes were made to produce the Charnley Kerboull prosthesis which was polished, tapered and with the neck angle increased to 130 degrees. A sufficient range of sizes was available so that after removal of the cancellous bone the implant selected most accurately restored the hip architecture. It was not considered essential to take always the largest stem but rather to use the size that best suited the patient’s requirement. If a large stem were required, little room would remain for the cement which may indeed contain windows [6].

It was considered that in this way the desired component alignment could be reproducibly obtained and the cement maintained in compression. Even when the stem produced a thin cement mantle on the anteropos-
terior radiograph, it might be thicker on the lateral view and sometimes the cement would be uniformly greater than 2 mm in thickness. Outcome studies summarised in a recent paper [5] have shown that this philosophy has produced excellent long-term results (except when fashion determined changes in the surface roughness where made). The MK, mark I had an aseptic loosening rate of 1 to 2% at 20 years and the MK III a zero percent aseptic loosening rate at 10 years [4]. It is not without interest that this technique did not succeed when the stem was considerably roughened in the CMK III with 21% aseptic loosening at 10 years [5]. This is analogous to the behaviour of the Exeter stem when it is roughened [3]. It would seem that the success of the Kerboull approach lies partly on the considerable compression of the cement generated by hammering a tightly fitting implant into the dough like material producing an interlock with the femur and partly (but more importantly in MK’s opinion) on the polished surface finish which even in the event that debonding occurs will not produce particulate debris, and a tapered geometry that will continue to exert compressive forces on the cement bone interface under load.

A visiting French surgeon introduced the concept of ‘thin’ cement to Michael Freeman and it has been taught as the method for securing his neck retaining prosthesis when cement is used. This prosthesis is tapered in its proximal section where it engages the retained metaphyseal bone and polished distally in its conical section. As the femur is prepared by milling tools, a precise cavity is prepared of the same dimensions as the intended implant. However, it should be noted that unlike the Kerboull method, there is no emphasis on removing all the proximal cancellous bone. When the implant is introduced into the cement filled femur it creates pressurisation as there is nowhere for the cement to escape and the implant is forced to line up correctly in the prepared bone. A further difference is that the conical distal portion of the stem is not intended to produce a distal jammed press-fit with minimal cement augmentation as resistance to torsional forces is afforded by the retained neck, hence the distal section is not required to have a rectangular section. A clinical and experimental report [8] compared the results of cementing this implant after deliberately ‘over-reaming’ by 2 mm to provide space to accommodate a minimum thickness of 2 mm cement mantle and an alternative method of using the implant after reaming to size and cementing directly without any space reserved for cement. The clinical study showed no significant difference in the clinical outcome or in the survival rate (approximately 98% at 10 years) of the two methods. Thigh pain was not observed. Estimates for thickness could not be made reliably from radiographs due to the variability within particular zones and in places the lack of distinction between the margin of the cement and the surrounding cortical bone (whiteout). What was found was a higher incident of radiolucent lines and lytic lesions in the »over-reamed« group. A cadaveric study involved examining transversely sectioned femora which had been either 2 mm over-reamed or reamed to size prior to cementing a Freeman stem.

Fig. 8.27. a Freeman stem immediately postoperatively with »thin« cement. b The same implant as a 10-years postoperatively
Chapter 8.6 · Femoral Components: The French Paradox

Fig. 8.28. a Freeman stem with »thick« cement immediately postoperatively. b The same implant as a 12 years post-operatively following an isolated acetabular revision.

Fig. 8.29. a Transverse cuts of a cadaveric femur with »thin« cement showing the presence of windows at various locations. b As in a but with thick cement. (Note in both specimens on some slices the epoxy resin used to surround the femur to enable cutting is still in place.)
These sections showed that around the proximal half of the implant the cement thickness was not significantly different between the two methods of femoral preparation with an average cement mantle of 3 to 4 mm in thickness. The lack of difference could only have arisen due to greater ingress of the cement in the less reamed femur. In turn this greater penetration must have occurred because greater pressurization was achieved. It was only in the distal conical section that the «over-reamed» femora had a significantly thicker cement mantle. Further, in both groups but more commonly with thin cement, windows were found in the cement which would not have been detected on an anteroposterior radiograph.

Thus, these observations give room for controversy. By attempting to emulate the method of Kerboull it transpires the Freeman ‘thin’ techniques conforms to the

![Fig. 8.30. a MK, mark I stem at 1 year post op with 'thick' cement. b Same prosthesis as a at 22 years post operatively](image)

![Fig. 8.31. a,b AP and lateral views of a large MK III stem at 6 years post op. c The same prosthesis as a,b at 16 years post operatively](image)
prevailing view on the preferred thickness of cement, as does the ‘thick’ technique, but the thin method produces better pressurisation, resisting the venous pressure maintaining the pressurisation as the implant is subsequently introduced. This deeper engagement of the cement into the bone appears to provide some resistance to the production of radiolucent lines and lytic defects. On the other hand, the method of Kerboull sometimes produces thinner distal cement but the absolute thickness of the proximal cement is not known for certain as the radiographs cannot provide this information with certainty and cadaveric measurements have not been made. However, how thin or thick the cement mantle might be has not been the prime objective of the Kerboull method but more a by-product. Nevertheless, some matters do seem to be obvious, pressurisation of the cement is advantageous and if movement is anticipated, an implant finish which avoids particle generation is preferred.

The authors accept that the French use of »thin« cement may be specific to the features of certain implants but comment that at least with some prostheses, even if the cement is »thin«, the result is no worse than when cement is used in the classical manner.

The thickness of the ideal cement mantle remains debatable.

»Thinner« cement mantles can produce excellent long-term fixation as evidenced by 2 different prosthetic designs reported here. Both these stems produce considerable cement pressurisation when they are inserted into the cement filled proximal femur as they do not allow the cement to escape.

A cadaveric study with the Freeman stem has shown that breaches in the cement mantle can be underestimated from the antero-posterior radiographs.

Additionally, the cement mantle that might have been expected to be thin, as no supplementary space was made for the cement at femoral preparation, was in fact thicker than suspected when direct measurements were made from transverse slices of the bone.

Even when the stems produce a thin cement mantle distally on the antero-posterior radiograph, it might be thicker on the lateral view.

Proximal cement mantles are usually thicker, even with »distally press-fitted« stems.

**References**


**Take Home Messages**

- The thickness of the ideal cement mantle remains debatable.
- »Thinner« cement mantles can produce excellent long-term fixation as evidenced by 2 different prosthetic designs reported here. Both these stems produce considerable cement pressurisation when they are inserted into the cement filled proximal femur as they do not allow the cement to escape.
- A cadaveric study with the Freeman stem has shown that breaches in the cement mantle can be underestimated from the antero-posterior radiographs.
- Additionally, the cement mantle that might have been expected to be thin, as no supplementary space was made for the cement at femoral preparation, was in fact thicker than suspected when direct measurements were made from transverse slices of the bone.
- Even when the stems produce a thin cement mantle distally on the antero-posterior radiograph, it might be thicker on the lateral view.
- Proximal cement mantles are usually thicker, even with »distally press-fitted« stems.

**Acknowledgements.** The authors wish to thank Dr Mark Taylor for supplying the sections of femur in the experimental study.