Incomplete cement mantles in the sagittal femoral plane

An anatomical explanation

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The influence of operative technique on the formation of incomplete cement mantles in the sagittal plane has been rarely considered in the literature. In this article, we discuss the influence of the anatomy of the proximal femur on the formation of incomplete cement mantles and discuss how their incidence can be reduced by correct component positioning.

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The importance of an even cement mantle around femoral components, when viewed on AP radiographs, has been appreciated. Recommendations on implant sizing and operative technique to reduce the incidence of incomplete cement mantles in the coronal plane are widely discussed (Egund et al. 1990, Star et al. 1994). However, the same does not appear to be true of cement mantle defects, seen only on lateral radiographs, and it is important to appreciate how these defects may occur. The aim of this paper is to demonstrate how incomplete cement mantles may be produced at the middle and tip of femoral components.

There has been an almost complete disregard in the literature concerning the influence of the sagittal anatomy on the completeness of the cement mantle around femoral components. To understand how defects in the cement mantle can occur, we examined a series of 18 cases of cemented femoral components with incomplete cement mantles, seen only on lateral radiographs, and then modeled the anatomy of the proximal femur in the sagittal plane to explain their distribution.

Results

In all cases when a defect in the cement mantle was observed around the middle of the stem, the defect lay anteriorly, while at the stem tip the defect lay posteriorly (Figure 1). The presence of these defects was confirmed at revision surgery.

The anatomy of the proximal femur in the sagittal plane is complex, but can be simplified by considering 3 factors:

1. The femoral neck is anteverted and has an anterior bow.
2. The femoral shaft has a posterior bow.
3. The axis of the femoral neck is in front of that of the proximal femur (Figure 2).

Femoral neck anteversion is reported as ranging from 13 to 20 degrees (Pick et al. 1940, Reikerås et al. 1983, McMinn 1994) and is increased by 6 degrees in patients with osteoarthrosis of the hip (Reikerås et al. 1983). As well as being anteverted the femoral neck arises anterior to the axis of the medullary canal (Figure 2). The bow of the femoral shaft averages 8 degrees with its apex anteriorly (Harper and Carson 1987).

When a component is placed in the femur, at the point of the neck osteotomy, its axis lies well anterior to the axis of the femoral shaft. In fact, it has been determined from a cadaveric study that at the level of neck resection for a total hip replacement the mid-point of the femoral neck lies an average of 8 mm anterior to the projected medullary axis of the femur (Noble et al. 1988). This brings the anterior surface of the component close to, or against, the anterior endosteal surface of the

Figure 1. Femoral component passing from anteriorly in the femoral canal proximally to the posterior cortex at its tip.

Figure 2. Lateral radiograph of the proximal femur showing the femoral neck arising anterior to the medullary axis of the femur.

femur at or just below the lesser trochanter (Figure 2). Further distally, the bow of the femoral shaft, and the orientation of the stem imposed by the proximal femur, means that the tip of the component approaches, and may abut on the posterior endosteal surface of the femur (Figure 2).

Discussion

The finding of cement mantle defects anteriorly at the level of the lesser trochanter and posteriorly at the stem tip is in direct contradiction to a recent publication (Berger et al. 1997) which states that cement mantle defects in the sagittal plane occur posteriorly at the level of the lesser trochanter and anteriorly at the stem tip. In no case did we see this pattern of cement mantle defects. In the model of Berger et al., the fact that the femoral neck arises anterior to the mid-axis of the femoral shaft was ignored (Figure 2). We have demonstrated that the orientation of the femoral neck is an important determinant of component positioning in the sagittal plane and cannot be ignored. To ensure the most even cement mantle around a femoral component, it must be placed as posteriorly as possible at the level of the neck resection.

Improved stem alignment (Star et al. 1994) and stem-tip positioning (Egund et al. 1990) have been observed, with distal centralising. However, distal centralisers, while ensuring a complete cement mantle around the tip of the implant, will move the axis of the femoral component forward in the sagittal plane. It is important that the stem tip should be kept away from the posterior femoral cortex, but it should be appreciated that the further anteriorly the stem tip lies, the more likely an incomplete cement mantle in the proximal femur. Proximal centralisers have also been shown to improve coronal positioning of the femoral stem (Noble et al. 1991). However, since the mid-point of a femoral neck osteotomy lies anterior to the femoral shaft, a femoral component centralised proximally is more likely to be associated with an incomplete cement mantle anteriorly just below the lesser trochanter, than a component which is placed posteriorly at the level of neck osteotomy. Hence the use of distal or proximal centralisers or expansion of prostheses proximally may lead to an increase in incomplete cement mantles, seen only on lateral radiographs.

The cement mantle, when viewed on the sagittal plane, is more likely to be complete if the stem is placed posteriorly in the canal at the level of neck

resection. This is more difficult through an anterolateral approach than a posterior approach, since with the former the abductors need to be retracted posteriorly. Furthermore, when approaching the femur from anteriorly it may be that the femoral neck will be divided perpendicular to its axis. This makes the posterior neck cut disproportionately high in relation to the anterior, meaning that, even if the stem is placed against the posterior cortex from an anterior approach, it still lies further anteriorly than with a posterior approach.

Other factors which make incomplete cement mantles around cemented femoral components more likely are femoral neck retention, which places the entry point of the component even further anteriorly, and long-stem femoral components. If surgeons wish to retain the femoral neck they must be aware that it will not always be possible to do so and at the same time ensure a complete cement mantle.

We conclude that the sagittal anatomy of the proximal femur is an important determinant of incomplete cement mantles around cemented femoral components, and that these defects occur anteriorly at the level of the lesser trochanter and posteriorly at the stem tip. Surgeons should be aware of this sagittal anatomy when performing total hip replacement. Only by correct positioning of the femoral component in the sagittal and coronal planes can incomplete cement mantles be avoided. This may lead to a decrease in femoral osteolysis and will make revision surgery easier by avoiding eccentric placement of the stem tip.

Berger R, Steel M, Wood K, Evans R, D'Antonio, Rubash H. Effect of a centralizing device on cement mantle deficiencies and initial prosthetic alignment in THA. J Arthroplasty 1997; 12: 434-43.

Egund N, Lidgren L, Önnerfalt R. Improved positioning of the femoral stem with a centralising device. Acta Orthop Scand 1990; 61: 236-9.

Harper M, Carson W. Curvature of the femur and the proximal entry point for an intramedullary rod. Clin Orthop 1987; 220: 155-61.

McMinn R M H. Last's anatomy regional and applied, 9th edition, Churchill Livingstone 1994.

Noble P, Alexander J, Lindall L, Year D, Granberry W, Tullas H. The anatomical basis of femoral component design. Clin Orthop 1988; 235: 148-65.

Noble P, Tullos H, Landon G. The optimum cement mantle for total hip replacement: Theory and practice. Instr Course Lect. American Academy Orthopaedic Surgeons. 1991: 145-50.

Pick J, Stack J, Anson B. Measurements on the human femur. Q Bull Northwestern Univ Med School 1940; 15: 281-90.

Reikerås O, Bierchreim I, Kolbensterdt A. Anteversion of the acetabulum and femoral neck in normals and in patients with osteoarthritis of the hip. Acta Orthop Scand 1983; 54: 18-23.

Star M, Colwell C, Kelman G, Ballock R, Walker R. Suboptimal (thin) distal cement mantle thickness as a contributory factor in total hip arthroplasty femoral component failure. J Arthrop 1994; 9: 143-9.