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ORIGINAL PAPER

Comparison of distal and proximal centralising devices in hip arthroplasty

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Abstract Centralising devices were introduced to ensure that the prosthesis is implanted in a neutral position and that a cement mantle of optimal thickness is achieved proximally and distally. A distal centralising device (DCD) is compared with a proximal midshaft centralising device (PCD) to test which one provides a more neutral prosthetic alignment. Thirty consecutive patients undergoing hemiarthroplasties for femoral neck fractures were studied prospectively. Patients were blindly randomised to receive either a femoral component with proximal midshaft centraliser or distal centraliser. Both components were implanted following the manufacturer's protocol. Postoperative true anteroposterior and lateral radiographs were made to assess the stem position. There was no statistically significant difference between the two groups in zones 1, 2, 3, 4, 5, 6 and 7 in both anteroposterior and lateral radiographic measurements. DCP and PCD both have similar centralisation and cement mantle. Future studies should be done to evaluate their long-term effect.

Résumé Objectif: un matériel permettant de bien centrer la prothèse a été utilisé de façon à avoir une prothèse en position neutre avec un manteau de ciment dont l'épaisseur doit être optimale aussi bien pour la partie proximale que distale. Le centralisateur DCD est comparé avec le matériel permettant de centraliser la prothèse PCD. Matériel et méthode: 30 patients consécutifs ont bénéficié d'une arthroplastie, après une fracture du col du fémur. L'étude a été prospective. Les patients ont bénéficié d'une randomisation en double aveugle de façon à recevoir soit un composant fémoral fixé par le centralisateur médio diaphysaire, soit un centralisateur distal. Les composants fémoraux ont été implantés selon les recommandations du fabriquant. Des radiographies face profil ont été réalisées de façon à évaluer la position de la queue de la prothèse. Résultats: il n'y a pas de différence significative entre les deux groupes dans les zones 1, 2, 3, 4, 5, 6 et 7 que se soit sur les radios de face ou de profil. En conclusion, DCP et PCD ont, toutes les deux, une fonction de centralisation et d'organisation du manteau de ciment. Des études ultérieures seront nécessaires pour évaluer les effets à long terme de cette technique.

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Introduction

Orthopaedic surgeons have been aware of the adverse effects of varus alignment for many years, but avoiding varus has remained a clinical problem. There is concern that a deficient cement mantle may be detrimental with regard to long-term implant survival. Cement mantle fractures may occur as a result and can be associated with osteolysis and granuloma formation at the interface [1, 11]. Clearly, the ultimate position of the femoral component will depend on many factors, principally correct exposure and preparation of the medullary canal; however, once adequate exposure and preparation of the femoral canal have been accomplished, the possibility of component malposition remains significant.

In view of the importance of the position and alignment of the femoral stem within the cement mantle, modular centralising devices were introduced [10]. These devices are fabricated from polymethylmethacrylate and reattached to the proximal and distal ends of the prosthesis. Their main function is to ensure that the prosthesis is implanted in a neutral position within the implantation cavity and that a cement mantle of optimal thickness is achieved proximally and distally without implant-bone impingement. In this study, a distal centralising device (DCD) is compared with a proximal midshaft centralising device (PCD) to test which one provides a more neutral prosthetic alignment.

Materials and methods

Thirty consecutive patients undergoing hemiarthroplasties for femoral neck fractures were studied prospectively. Patients were blindly randomised to receive either a femoral component with proximal midshaft centraliser (Stanmore Hip System, Biomet, Warsaw, IN, USA) or distal centraliser (Omnifit Hip System, Stryker, Kalamazoo, MI, USA). As a result of randomisation there was a total of 15 prostheses with DCD and 15 prostheses with PCD. Both components were implanted following the manufacturer's protocol.

All operations were performed by the same surgeon. A standard anterolateral approach was performed. The femur was prepared for the implantation of the prosthesis using three-step instrumentation consisting of distal reaming, conical midshaft reaming and proximal broaching. The third-generation cementing technique was used. The intramedullary plug was placed approximately 2 cm distal to the expected distal tip of the stem. A pulsating lavage system was used in all of the patients. Two types of standard viscosity cement, CMV (DePuy International Ltd., Blackpool, UK) and Palacos (Schering-Plough Ltd., Welwyn Garden City, UK), were used according to the availability. The cement was introduced from a gun followed by digital pressurisation. The distal centralisers were sized based on the largest reamer that was used in a patient. The central peg of the distal centraliser was inserted into the tunnel at the tip of the prosthesis. The size of the proximal centraliser corresponds to the difference in size between the proximal aspect of the broach and the stem. The proximal centraliser is circumferential in nature and fits around the stem in the distal two thirds of the stem.

Radiographic evaluation

Postoperative true anteroposterior (AP) and lateral radiographs were made to assess the stem position. An angular obliquity greater than 20° for either radiograph was considered unacceptable. For AP radiographs, an oblique view of the femoral component was evidenced by an apparent shortening of the prosthesis collar. In true lateral view, the collar of the prosthesis should appear to extend symmetrically both anteriorly and posteriorly about the prosthesis. For lateral radiographs, an asymmetry about the prosthesis of the collar greater than 15% was considered unacceptable. Any AP and lateral radiograph not meeting these criteria was rejected and new radiographs were obtained prior to marking [2].

The radiographs were assessed by two evaluators. The mean values of the measurements were noted. The cement mantle thickness was assessed for each AP and lateral zone as described by Gruen et al. [6] and Johnson et al. [8]. The average thickness of the cement mantle was measured within each Gruen zone.

The medullary axis was defined by the line of best fit passing through midpoints of the medullary canal in the AP view, measured at the level of the isthmus and at points 20 mm proximal and 20 mm distal to the isthmus. The medullary axis of the contralateral femur also was determined using this method. The prosthesis axis was defined by the axis of symmetry of the distal one half of the femoral stem on the AP radiograph. The orientation of the prosthesis within the femur was calculated as the angle between the prosthesis and medullary axes. The centres of the head of the prosthesis and the contralateral femur were determined using radiographic templates of transparent concentric circles. The medial offsets of the ipsilateral and contralateral femoral heads were defined by the perpendicular distance between the femoral medullary axis and the centre of the femoral head [5].

A radiographic magnification factor, calculated as a ratio between the measured and the actual diameter of the bipolar head, was used to correct all radiographic measurements to actual dimensions. The width of the intramedullary canal at the stem tip was measured and corrected for magnification to indicate that the canal shape was oval on AP and lateral radiographs.

Results

Implant position

Overall, in both PCD and DCD groups 14 of 15 femoral stems were implanted within 2° of neutral, whereas one stem was implanted within 3° of neutral in the PCD group and one stem implanted within 4° of neutral in the DCD group.

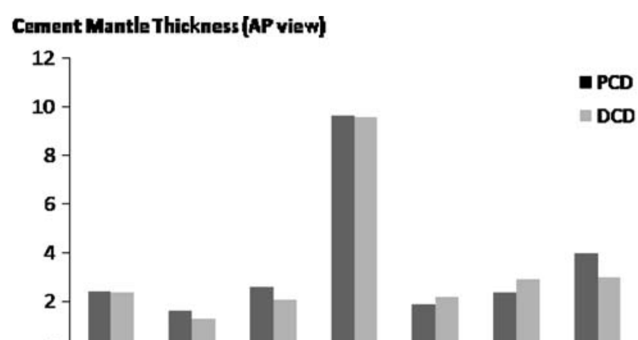
Cement mantle thickness

In the DCD group on the AP radiograph the mean cement mantle thickness in the Gruen zones was 2.37 mm (range: 0.50–4.0, SD: 1.27) in zone 1, 1.31 mm (range: 0.5–2.50, SD: 0.79) in zone 2, 2.06 mm (range: 1–3, SD: 0.86) in zone 3, 9.56 mm (range: 8–12 mm, SD: 1.45) in zone 4, 2.18 mm (range: 1–5, SD: 1.30) in zone 5, 2.93 mm (range: 1.5–4 mm, SD: 0.90) in zone 6 and 3.0 mm (range: 1–5 mm, SD: 1.30) in zone 7 (Fig. 1). In the lateral view the cement mantle was measured at 1.92 mm (range: 1–5 mm, SD: 0.42) in zone 1, 1.35 mm (range: 1–2.5 mm, SD: 0.62) in zone 2, 3.14 mm (range: 1–5 mm, SD: 1.34) in zone 3, 11.14 mm (range: 8–14 mm, SD: 2.26) in zone 4, 2.0 mm (range: 1–3 mm, SD: 0.57) in zone 5, 3.35 mm (range: 2–5 mm, SD: 1.18) in zone 6 and 3.14 mm (range: 1–6 mm, SD: 1.86) in zone 7 (Fig. 2).

In the PCD group on the AP radiograph the mean cement mantle thickness in the Gruen zones was 2.42 mm (range: 0.50–6 mm, SD: 1.44) in zone 1, 1.61 mm (range: 0–5 mm, SD: 1.19) in zone 2, 2.61 mm (range: 0.50–6 mm, SD: 1.70) in zone 3, 9.66 mm (range: 7–12 mm, SD: 1.37) in zone 4, 1.88 mm (range: 0.8–5 mm, SD: 1.35) in zone 5, 2.38 mm (range: 1–5 mm, SD: 1.26) in zone 6 and 4.0 mm (range: 0.8–9 mm, SD: 2.73) in zone 7 (Fig. 1). In the lateral view the cement mantle was measured at 2.86 mm (range: 2–5 mm, SD: 1.09) in zone 1, 2.27 mm (range: 1–3 mm, SD: 0.68) in zone 2, 2.90 mm (range: 1–7 mm, SD: 1.80) in zone 3, 10.72 mm (range: 7–13 mm, SD: 1.73) in zone 4, 2.31 mm (range: 1–7 mm, SD: 1.76) in zone 5, 2.63 mm (range: 1–5 mm, SD: 1.12) in zone 6 and 2.18 mm (range: 0.5–7 mm, SD: 2.22) in zone 7 (Fig. 2).

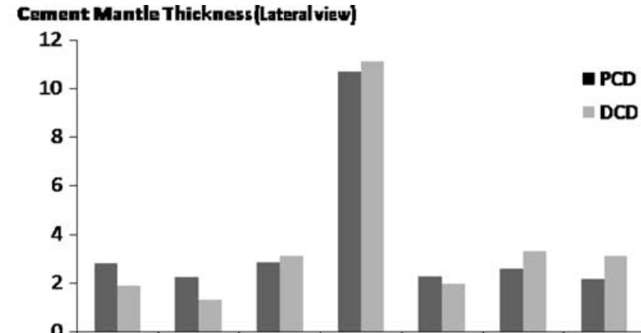
There was no statistically significant difference between the two groups in zones 1, 2, 3, 4, 5, 6 and 7 in both AP and lateral radiographic measurement of the cement mantle ($p<0.05$). The difference in cement thickness between zones 1 and 7 was almost two times higher than the other zones without a statistically significant difference in PCD ($p=0.69$).

When the centralisation was compared there was no statistically significant difference found in all zones in AP and lateral radiographic measurements in PCD and DCD.



	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7
PCD	2,42	1,61	2,61	9,66	1,88	2,38	4
DCD	2,37	1,31	2,06	9,56	2,18	2,93	3

Fig. 1 Anteroposterior measurements of cement mantle thickness



	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7
PCD	2,86	2,27	2,9	10,72	2,31	2,63	2,18
DCD	1,92	1,35	3,14	11,14	2	3,35	3,14

Fig. 2 Lateral measurements of cement mantle thickness

Discussion

The centralisation of the femoral component has an important role in stem loosening. The relationship between thin cement mantle and loosening in cemented femoral components was shown in a study with 836 cases. The adverse effects of a thicker or thinner cement mantle was reported [4]. Star et al. evaluated 100 cemented total hip arthroplasties (THAs) and reported the adverse effects of a suboptimal (thin) cement mantle at the medial diaphysis on stem loosening [13]. With regard to the relationship between a thin cement mantle and osteolysis Huddleston reported femoral lysis after cemented THA around femoral components. The process frequently started where metal abutted against bone or where cement was deficient or fractured [7]. Maloney et al. found that the area of osteolysis corresponded to either a defect in the cement mantle or an area of cement that was <1 mm thick. Kawate et al. found that there is risk of generating thin cement mantle with use of the triangular centraliser and its insertion into the stem tip [9]. In our study we tried to find out which device centralises the stem to form a unique cement mantle through the stem. A thin cement mantle has been defined as <1 mm on radiographs in some studies [5]. We used the same terminology in this study. The radiographic results show that a symmetrical cement mantle of adequate minimum thickness was achieved in most cases. In 14 of 15 patients (93.3%) in both groups the stem was inserted in an acceptable position, with varus alignment in excess of 2°

occurring in only two cases. These observations are important because the association of varus alignment of the femoral stem and suboptimal long-term results of cemented THA is well known [3, 12].

This study has shown the influence of centraliser design on cement mantle thickness and alignment of the stem. Distal centralisers seems to be efficient at the level of the stem tip but fail to prevent thin cement mantle proximally. Because of that, the difference in cement thickness in zones 1 and 7 was two times higher without a statistically significant difference in PCD.

DCD and PCD have similar effects on cement mantle thickness and alignment of the stem. The long-term results of these two devices should be evaluated in future studies.

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