International Orthopaedics (SICOT) (2002) 26:166–169
DOI 10.1007/s00264-002-0355-3

ORIGINAL PAPER

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The effect of a lateral flare feature on implant stability

Accepted: 19 February 2002 / Published online: 20 April 2002

Abstract We reviewed the X-rays of 109 patients with 115 primary total hip replacements utilizing a lateral flare cementless stem to assess axial migration and stability. The average follow-up was 48.6 (24–104) months. The average subsidence at 2 years was 0.32 mm, remaining at a level below 1 mm for the duration of the follow-up. Even though there were ten reoperations involving either the change of a polyethylene liner and the acetabular component, or both, none of the patients required a femoral stem revision. It was concluded that the proximal geometry of the stem provides significant initial stability, which seems to be preserved throughout a long follow-up period.

Résumé Nous avons examiné les clichés de 109 malades avec 115 prothèses primaires de la hanche utilisant une tige fémorale non cimentée avec évasement latéral pour contrôler la migration axiale et la stabilité. La moyenne de suivi était 48.6 mois (24 à 104 mois). L'enfoncement moyen à 2 ans était 0.32 mm., restant en dessous de 1 mm pendant la suite de l'évolution. Bien qu'il y eût 10 ré – opérations pour changement de l'insert en polyéthylène et/ou du composant acétabulaire, aucun des malades n'a eu besoin d' une révision de la tige fémorale. Il a été conclu que la géométrie de la tige proximale donne une bonne stabilité initiale qui paraît être conservé pendant une longue période.

First presented at the SICOT/SIROT conference, Paris, France, 2001

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Introduction

Since the development of the total hip arthroplasty, subsidence has been used as a means to predict long-term survival of the prosthesis [5]. It has been a useful tool in analysis of new prostheses early in their life because it is a reliable early predictor of failure. Malchau et al. showed that the greater the migration found by the 1-year follow-up, the higher the risk of revision [8]. Roentgen stereophotogrammetric analysis (RSA) has demonstrated a high incidence of subsidence in cemented and noncemented stems in the first 4–6 months. The amount of subsidence diminishes over the next year and one-half and then becomes insignificant in most successful stems.

The lateral flare femoral stem features a proximal lateral expansion, which was designed to engage the lateral cortex of the femur in the metaphysis, allowing for a more concentric loading in the proximal femur [3]. The use of a 'proximal plug' configuration relieves distal stress transfers and is inherently stable [10]. The same geometry demonstrates comparable behavior in the revision setting, along with significant preservation of the preoperative bone stock [12].

The purpose of the present study was to assess axial displacement values of a series of total hip arthroplasty in which a lateral flare cementless femoral component was used. The emphasis of this report was placed on the femoral component.

Materials and methods

The inpatient and outpatient records and radiographs of 101 patients who underwent 115 total hip arthroplasties from June 1992 through December 1998 were reviewed. Inclusion criteria for this study were a minimum of a 2-year follow-up from the first postoperative office visit and the absence of a femoral shaft osteotomy or fracture at the time of surgery. There were 62 men and 39 women patients with an average age of 60.6 (28–80) years. Fourteen patients had bilateral procedures. The preoperative diagnoses included 68 hips with osteoarthritis, 22 revision arthroplasties, 11 hips with aseptic necrosis, 13 hips with osteoarthritis secondary to developmental dysplasia (DDH), and one acute femoral neck fracture. The average follow-up was 48.6 (24–104) months.

An initial postoperative radiograph was always obtained in the recovery room with a portable X-ray machine. It is our policy to document all postoperative implants in the recovery room and assure that total joints are reduced and grossly well positioned. However, due to differences in technique and rotation, this film was not used as the index film. Instead, the first X-ray taken at the initial postoperative office visit was used for the index measurements. This film was usually taken at the 2-week postoperative visit. Follow-up was calculated from the date of this index film. Typically, the patients are followed radiographically yearly thereafter.

Axial migration of the femoral component was assessed using a previously described method [11]. After digitization of the radiographs, the distance from the tip of the greater trochanter to a reference point in the stem was measured. The lateral flare of the stem is a noticeable and constant proximal feature, thus the measurements were made from the apex of the lateral flare of the prosthesis to a reproducible bony landmark in the greater trochanter present on both films. The vertical distance between the two points was then measured on each film, and the difference was calculated as a measure of the distal subsidence of the prosthesis. Three different sets of readings were made on each digitized film. The reported subsidence represents the average value of each set of measurements. The intraobserver error was calculated to be 0.32 mm.

Prosthesis

All prostheses had the same extended proximal geometry (Fig. 1). There were 76 custom-made implants (Stanmore Implants, Stanmore, UK) and 33 ‘off-the-shelf’ stems (Revelation Hip, Encore Medical, Austin, TX). Customized prostheses were proximally coated with hydroxyapatite, or grit blasted and designed for noncemented implantation. The ‘off-the-shelf’ version was porous coated in the proximal one third. Metaphyseal medial-lateral dimension of the stem was wider than the diaphyseal diameter of the femur, allowing for a much broader base of support in the metaphysis (Fig. 1). This feature, or “lateral flare,” was conceived as a direct consequence of dynamic lower extremity biomechanical models and studies [2]. Its design was specifically intended to engage the endosteal surface of the lateral femur at or above the intersection point of the mid-femoral-neck axis, as well as the medial cortex of the femur simultaneously [3]. The distal stem is short, tapered, and polished and is used to ensure proper alignment within the femoral canal, minimizing distal contact and load transfer.

Fig. 1 Typical X-ray of a lateral flare stem. Engagement of the lateral and medial femoral cortices creates a broader base of support for the device

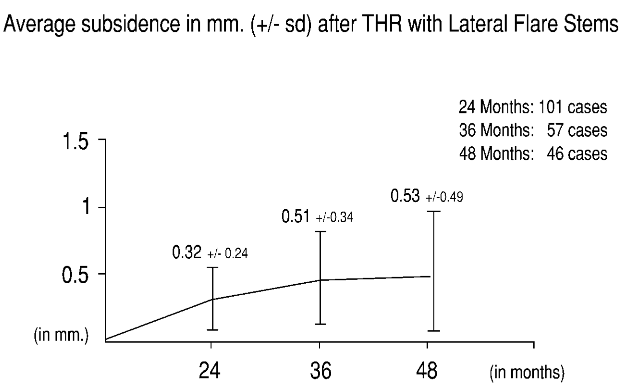

Fig. 2 Average subsidence in millimeters (+/-SD) after total hip replacement with lateral flare prosthesis

Results

There were 101 cases available for measurement at 2 years follow-up, 57 cases at 3 years, and 46 cases at 4 years. Based on radiographic measurements, average subsidence was 0.31 mm (SD 0.24 mm) at 2 years, 0.51 mm (SD 0.34 mm) at 3 years, and 0.52 mm (SD 0.49 mm) at 4 years. The stem seemed to reach a plateau of maximum subsidence before the 2-year mark with little or no axial displacement thereafter. Temporal progression of the values is shown in Fig. 2. There were no significant differences between the custom-made hydroxyapatite-coated lateral flare implants and its “off-the-shelf” porous-coated counterpart.

There were ten polyethylene liner failures requiring revision of the acetabular component. No patient required revision of the femoral component due to aseptic loosening. One patient suffered a periprosthetic fracture after a fall, requiring revision surgery with a longer stem.

Discussion

The concept of “rest fit”

Aseptic loosening is the most common long-term complication after both cemented and noncemented hip arthroplasty. More than 80% of failed implants that needed revision were linked to loosening and periprosthetic

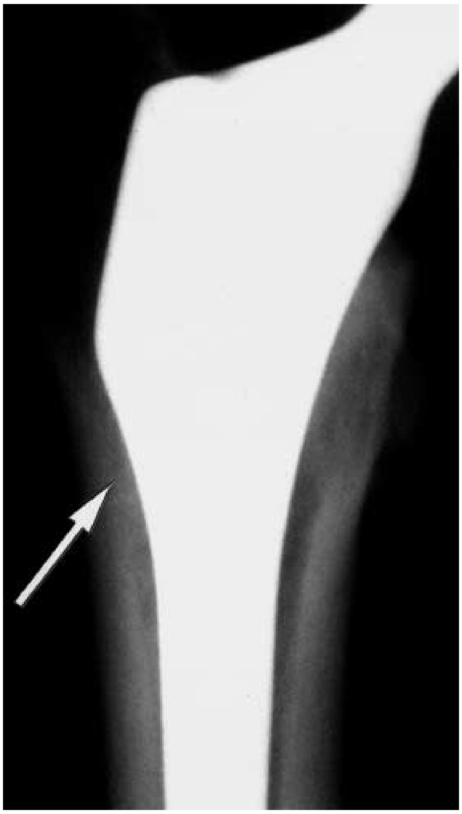

Fig. 3 View of the lateral flare feature resting on top of the lateral cortex, and the bone response elicited

Fig. 4 Concept of 'rest fit'. Left: A lateral flare stem rests on top of the medial and lateral femoral cortices. Right: A straight stem must rely on the medial cortex or the femoral diaphysis to achieve initial stability

bone loss [6]. This occurred at either interface in cemented (cement-implant or cement-bone) and noncemented stems. Periprosthetic bone deficits represent a critical factor in the subsequent loss of support and integration of the femoral component.

It is widely accepted that the design and geometry of the implant impacts its ability to transfer loads to the femur [10]. Consequently, the geometry of the femoral component plays a pivotal role in explaining periprosthetic bone loss due to stress shielding [9]. Because of the lateral flare geometry, loads in the proximal femur are more evenly distributed [10]. The lateral flare component rests upon an additional lateral column of cortical bone, stabilizing it against subsidence (Fig. 3). This additional lateral contact area creates a wider base of support and has been proven to help provide a more physiologic load distribution in the proximal femur [3, 2, 4, 10].

Femoral components that engage the metaphysis and load the femur both medially and laterally are inherently more stable [1, 4, 12]. The stem does not need to be 'press-fitted' into the femur or driven distally (interference fit) in the diaphysis to achieve initial stability. As the 'metaphyseal' diameter of the stem is appreciably wider than the diaphyseal diameter of the femur, the stem tends to rest upon the proximal lateral and medial cortices. We have termed this particular type of fixation 'rest fit' (Fig. 4).

Our findings correlate with previous clinical prospective studies [10, 12], which demonstrate more than 95% bone preservation of the proximal femur and less than 1 mm of femoral component subsidence 4 years after surgery, despite the fact that all the patients were permitted immediate full weight bearing on uncemented stems.

It is clear from prior studies that subsidence is one indicator of success of a femoral prosthesis in total hip arthroplasty. It is the only parameter where 2-year follow-up correlates with long-term success [8]. The error in measurement is very dependent upon what bony landmarks are used for measurements. It is our belief that a radiographically reproducible bony landmark is the best choice for measurement. Any one landmark is subject to ectopic bone formation [5, 7] or bone resorption; this was seen in a number of our patients who had iliopsoas releases and subsequent resorption of a significant portion of the lesser trochanter. When a reproducible landmark is identified, a single pinpoint can be used from which to make the measurements, thus increasing accuracy of the values. Moreover, use of the shoulder of the prosthesis has been shown to be much more accurate than the use of the femoral head center for measurements of the prosthesis [7]. In this series we used the tip of the greater trochanter and the outermost point of the flare of the stem as constant and reproducible landmarks in all cases.

The results if this study suggest that additional loading of the lateral cortex of the proximal femur may be beneficial in preventing subsidence, as it appears to be less disruptive to the natural loading of the femur. This first report reviews the behavior of the stem throughout a significantly extended period postoperatively and clearly demonstrates that this prosthesis does not subside appreciably. We believe this substantiates the theoretical biomechanics that led to the design of this prosthesis.

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