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A Surgical Technique for the Prevention of Femoral Lysis in Cement Total Hip Arthroplasty

Operační technika umožnující prevenci resorpce stehenní kosti po cementované náhradě kyčle

A. SARMIENTO, L. L. LATTA

Department of Orthopaedic and Rehabilitation University of Miami School of Medicine, Miami, USA

ABSTRACT

Femoral bone lysis in total hip arthroplasty is thought to be primarily due to polyethylene or metal debris arising from the femoral or acetabular components. The debris appears to gradually seep into the cement/ bone interface, eventually generating the chemical reaction that produces lysis. We experimented with a surgical technique that attempts to construct a proximal bony barrier preventing migration of debris. Following the injection of the acrylic cement and the insertion of the femoral component, but prior to complete polymerization of the cement, bone chips are pressed over the cement, in contact with the viable femoral cortex. The bone chips become rigidly fixed; probably regain viability from the femoral cortex, and seal the proximal femur. In this manner, debris cannot travel into the femoral canal. Although we do not have anatomical evidence that a viable bony seal has formed the absence of lysis and bone/cement radiolucent lines over a period of time ranging from three to fourteen years suggests the permanent presence of a physiological barrier. Attempts to identify the permanency of the bony seal by means of CT scans proved inconclusive.

Key words: total hips, lysis, femoral lysis, cortical graft.

INTRODUCTION

It is currently agreed that following total hip arthroplasty, polyethylene or metal debris depositing against the cortical femoral cortex or against the cancellous surface in the acetabulum is responsible for the production of lysis. The debris initiates a chemical reaction that in most instances is progressive in nature, and can be severe enough to loosen the prosthetic components and/or create significant bone damage. Attempting to overcome this insidious problem, new polyethylenes have been manufactured (7). Though there is no long-term evidence of a superior in-vivo performance of the new materials, mid-term clinical experiences and laboratory performance are encouraging. Others have developed noncemented femoral prostheses that by virtue of their design attempt to prevent the migration of debris into the medullary canal. These prostheses have porous surfaces into which bone is expected to grow, reinforcing in that manner the possibility of creating a more effective barrier. We are not aware of any attempts having been made by others in regards to cemented arthroplasties. This explains the lack of references throughout the text. The technique we have used in this study, which consists of placing a bone graft over the still polymerizing cement in order to create a barrier, appears to prevent the distal seeping of debris into the bone-cement interface as depicted by the fact that lysis or radiolucent bone-cement lines have not been observed during a follow-up ranging between 3 and 14 years.

MATERIAL AND METHOD

Following preparation of the medullary canal, injection of acrylic cement and insertion of the prosthetic component, small fragments of bone removed from the femoral head, or obtained from the bone bank, are firmly pressed into the exposed, still doughy cement around the base of the neck of the metallic implant (Fig. 1). The

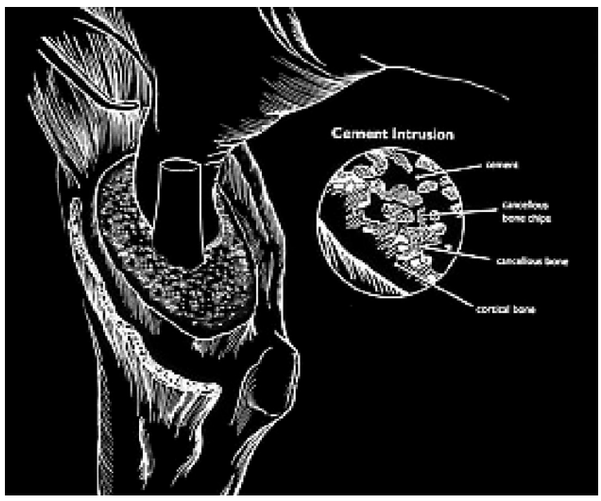
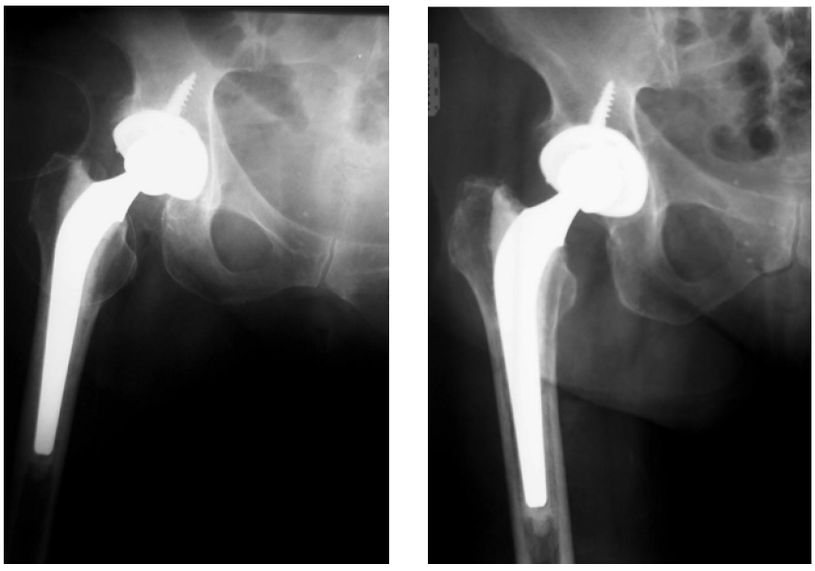


Fig. 1. Schematic drawing depicting the pressing of bone chips on the surface of the still doughy acrylic cement surrounding the base of the prosthetic stem. Notice that the bone chips are in contact with the femoral cortex.



a b

Fig. 2. Radiograph of a titanium alloy (STH-Zimmer) cemented femoral component immediately after surgery (a), and 14 years later (b). Bone chips had been firmly pressed over exposed surface of acrylic cement at the "mouth" of the proximal femur. Notice the absence of bone/cement, metal/cement radiolucent lines or lysis.

graft particles cover the entirely exposed cement surface, and are in close contact with the cortical wall of the femur. When the cement is fully polymerized the bone graft is permanently held in place. We anticipate that with time the graft regains its viability from blood supply arising from the normal femoral bone. The procedure was performed in 53 osteoarthritic hips. In all instances the acetabular components were porous ingrowth implants that were fixed without cement. The first 15 (28.3%) procedures were performed at the Orthopaedic Hospital of Los Angeles between July 1992 and September 1993; and the remaining 38 (71.6%) procedures were performed at Doctors' Hospital in Coral Gables, Florida between January 1999 and February 2001. The 15 (29.4%) prostheses inserted in California were made of a Titanium alloy (STH Zimmer, Warsaw); the 36 (71.1%) prostheses implanted in Florida were made of a Cobalt-Chrome alloy (Smith- Nephew, Memphis). The use of Titanium alloy femoral stem prosthesis, which was designed by us, was eventually discontinued after recognizing a higher failure rate with these implants, due probably to its softer nature that set the stage for scratching and subsequent debris production (3). The oldest patient was 88 years old, and the youngest 49. The median age was 74 years and the mode was 70 years. Thirty-four (64%) patients were 70 years of age or older. Thirty- eight (71.6%) patients were female and 15 (28.3%) were males.

Of the thirty-eight female patients in this group, thirteen ((34.2%) were younger than seventy years, and twenty-five (65.7%) were older than seventy years. Of the fifteen male patients in this group, six (40%) were younger than seventy-years and nine (60%) were older than seventy years.

Forty four (83 %) femoral stems were inserted in a neutral attitude; 5 (9.4%) stems in mild varus; and 4 (7.9%) stems in mild valgus. The femoral canal/stem ratio, measured at 7 cm below the base of the neck was

Fig. 3. Radiograph of bilateral titanium alloy (STH-Zimmer) cemented femoral stems simultaneously performed obtained 14 years after surgery.

50% in 20 (37.7%) arthroplasties; more than 50% in 27 (50.9%) arthroplasties; and <50% in 6 (11.3%) arthroplasties. The thickness of the column of cement at the level of the transected femoral neck measured < 3mm in 11 (20.7%); between 3-5mm in 38 (71.6%) and >5 mm in 4 (5.5%). The orientation of the acetabular component was at 45 degrees in 30 (56.6%) arthroplasties; > 45 degrees in 7 (13.2%); and < 45 degrees in 6 (11.3%) arthroplasties.

The small number of patients in this series may be explained primarily on the fact that when the study was getting underway, we had begun to perform non-cemented total hip arthroplasties with increasing frequency. The hiatus between 1992 and 1995 was due to the senior author relocating in another locality, during which time the procedure was not performed.

Fig. 4. Radiograph of cobalt-chrome (Smith-Nephew) cemented femoral component showing what appears to be live bone over the cement column. Film was obtained 6 years post-operatively. No lysis or radiolucent lines are present.

a

b

Fig. 5. Radiograph of a cobalt-chrome alloy (Smith-Nephew) cemented femoral component obtained shortly after surgery (a), and radiograph obtained 5 years later (b).

RESULTS

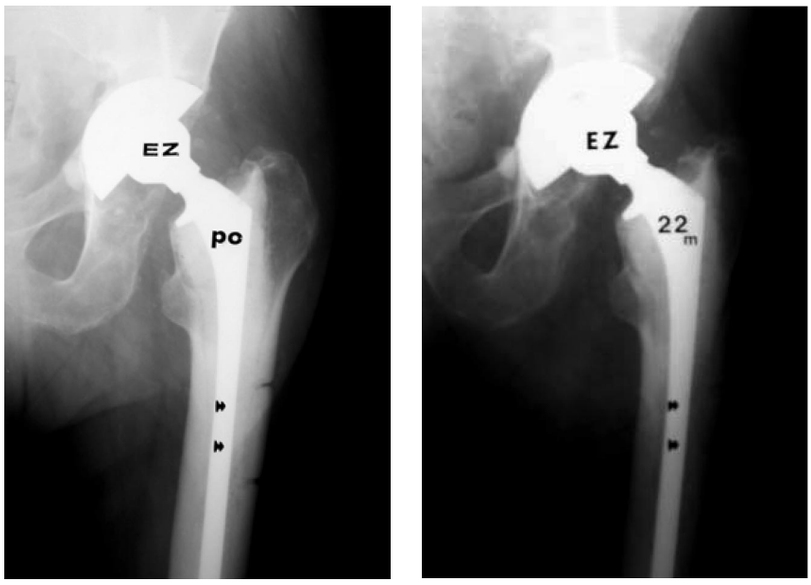
Most patients had radiographs of their hips at one-year intervals. The longest follow-up was 14 years, with a median of 6 years and modes of 7 years. Forty-one (77.3%) patients had a minimum follow-up of 3 years. Only the results observed in this group of 41 patients with a minimum follow-up of three years are reported. Thirty nine (95.1%) of these patients had a minimum follow-op of 4 years. The sub-group of 12 (22.6%) patients with follow-up < 3 years was made of 3 (25%) patients who expired during that period of time, and 8 (66%) patients who were lost to follow-up. In the group of 41 patients with follow-up >3 years 7 (17%) patients have expired or presumed dead because of their advanced age when the surgery was performed. One (1.8%) arthroplasty was revised six years after surgery at another institution, allegedly after alleged rather rapid deterioration of the hip joint. The mode of failure was not known to us. There were no infections or dislocations. One (1.8%) patient had a nonfatal pulmonary embolism. In the group of 41 (77.3%) arthroplasties who had a minimum follow-up of three years, neither radiolucent lines at the bone/cement interface, nor cement/metal radiolucent lines were observed in any patient. There were no radiologically recognized fractures of the cement, migration of the stem or cancellization (Fig. 2, 3, 4, 5, 6). Femoral lysis was not identified, unless one wishes to consider a lytic process a 3 mm resorption of the calcar seen in 1 (2.4%) arthroplasty. In this patient a titanium alloy prosthesis had been used; the stems was in neutral attitude, the stem occupied >50% of the canal at 7cm below the base of the prosthesis and the thickness of the column of cement at the level of the transected femoral neck was <3 mm (Fig. 7). Migration of the acetabulum has not been identified. In the group of 44 arthroplasties with follow-up > 3 years, wear of two millimeters was measured in one (2.2%) hip, 10 years after surgery. This patient did not show femoral lysis or any of the other changes discussed in the text.

a

b

Fig. 6. Radiograph of titanium alloy (STH- Zimmer) obtained shortly after surgery (a), and radiograph obtained 12 years later (b).

Fig. 7. Radiograph of proximal femur in a cemented titanium alloy (STH-Zimmer) total hip arthroplasty demonstrating the greatest degree of bone resorption found in the study.



a b

Fig. 8. Radiograph taken shortly after replacement of a bony window that had been surgically created to facilitate the removal of a failed arthroplasty. The bony window was pressed over the still doughy acrylic cement (a), and radiograph obtained nine months later showing incorporation of the window into the femoral cortex (b).

Fig. 9. Photograph of microscopic evidence of incorporation of the bone graft with the femoral cortex.

DISCUSSION

This article's major flaw is that it is not a prospective, randomized study. It is simply the summary of a relatively small series of patients who underwent total hip surgery using a surgical technique that theoretically should assist in reducing femoral lysis. Therefore, final and definitive conclusions cannot be drawn from the reported results. Hopefully, however, the clinical results thus far observed might stimulate further research on the subject.

At the present time lysis of the femur and/ or acetabulum is one of the most common complications in total hip arthroplasty, both in cemented as well as non-cemented types (1, 3, 11). The concept of creating a physiologically constructed mechanical barrier against femoral migration of debris from the polyethylene and metal acetabular components came from the recognition of the well-accepted belief that debris was responsible for the production of lytic changes that may accompany total hip implants. We were aware of efforts to overcome the problem through the use of noncemented implants that attempt to seal the "mouth" of the proximal femur (4, 9, 10). However, we extrapolated that no matter how tightly a non-cemented prosthesis fits the medullary canal it cannot prevent the migration of microscopic particles of metal or polyethylene debris, particularly in light of the fact that bone ingrowth does not take place throughout the entire porous surface (2). This extrapolation is supported by the fact that noncemented prostheses have not eliminated bone lysis. In the case of cemented implants, perfect contact of cement with the endosteal surface of the femur is probably never obtained. It is likely that the temporary devascularization of the endosteum from the mechanical and thermic injury created at the time of surgery might leave a "gap" thought which debris can seep distally. The incidence of femoral lysis in total hip replacement has been reported to range between 5% and 15% (1, 2, 4, 5).

On several previous occasions the senior author (AS) had replaced temporarily created "windows" made in the femur in order to remove cement and implants that had failed. Rather than fastening the bony fragment with wires or cables upon completion of the surgical procedure, he chose to press the removed fragment over the still polymerizing cement. The stability obtained was

thought to be good. The fragment healed against the host femur in all instances (Fig. 8). The possibility of obtaining a similar response when bone graft was pressed over polymerizing cement around a prosthetic implant attracted our attention. Since we were not in position to reproduce the technique in the hip of experimental animals we performed windows in the shaft of anaesthetized sheep, where their medullary canals had been filled with a metal rod and acrylic cement, over which bone chips were pressed prior to complete polymerization. Specimens obtained demonstrated incorporation of the bone fragment with the surrounding femoral bone, in the same manner we had observed in clinical practice (Fig. 9). We are keenly aware of the differences between the anatomo/physiologic conditions governing the two local environments, but have assumed that blood supply from the viable cortex, in the case of the described technique, may be comparable to the blood supply coming from the surrounding soft tissues in the case of the repositioned graft in revision surgery.

The use of newly developed cross-liked polyethylenes is expected to further improve the wear properties of the materials in vivo (7). However, sufficient time has not yet elapsed to conclude their superiority. If results from the new polyethelens prove to be superior, the incidence of lysis will further decrease, even some debris will continue to be produced. If the system we have developed provides the anticipated biological/mechanical seal, femoral lysis produced by debris should be further reduced. Questions remain concerning the fate of the bony acetabulum, since the procedure does not offer any protection to this component. However, none of our patients had shown thus far evidence of acetabular lysis. The virtual absence of lysis or bone/cement radiolucent lines in this small series composed of Titanium and Cobalt-Chrome alloys suggests the possibility that the bone graft incorporates with the viable femoral cortex, creating therefore a mechanical/physiological barrier to debris, which necessarily is generated from the acetabular polyethylene liners and metallic components (2, 5, 8, 9, 10, 11). We recognize that not enough time has elapsed to justify claims of success with the proposed technique, or that the possibility exists that the same results could have been obtained if the grafts had not been used. To support this claim, one can extrapolate that the reason for the success was due to the fact that the various features referable to the relationship between the cement, implant and acetabulum and femoral canal came very close to meeting the criteria considered ideal for attainment of high success (1, 3, 4, 6). Although CT scans have not convincingly confirmed the survival of the graft because of the close proximity of the graft to the metallic stem, plain radiographs have, on occasion, shown the bony lid (Fig. 4)

ZÁVĚR

Za příčinu resorpce stehenní kosti při totální náhradě kyčle jsou považovány především polyetylenové a kovové částice uvolněné z femorální nebo acetabulární komponenty. Tyto částice postupně pronikají do styčné plochy mezi kost a cement a mohou vyvolávat chemickou reakci, jejímž výsledkem je resorpce. Naši experimentální operační technikou jsme se pokusili postavit migrujícím částicím do cesty proximální kostní bariéru. Po injekci akrylového cementu a zavedení femorální komponenty, ale dříve než nastala dokonalá polymerizace cementu, byly do cementu vtlačeny kostní štěpy tak, aby zůstaly v kontaktu s kortikou (corticalis) stehenní kosti. Kostní štěpy jsou pevně fixovány a tím, že se pravděpodobně přestaví a obnoví svou funkci, proximální konec stehenní kosti uzavřou. Tím je částicím zabráněno pronikat do femorální dutiny. Ačkoliv nemáme anatomický důkaz, že se vytvořil funkční kostní uzávěr, nepřítomnost resorpce a radiolucentních linií na styku kosti a cementu ve sledovaném období od tří do 14 let ukazuje na trvalou přítomnost fyziologické překážky. Snahy potvrdit přítomnost tohoto kostního uzávěru pomocí CT vyšetření (výpočetní tomografie) neměly jednoznačné výsledky.

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Prof. Augusto Sarmiento, M.D.,
Department of Orthopaedic and Rehabilitation
University of Miami School of Medicine
D-27 P.O.Box 016960 Miami,
F1. 33101 USA