G.I.O.T. 2002;28:221-6

Cemented total hip arthroplasty: the SP-II femoral component*

P. Lubinus
W. Klauser
B. Schwantes
R. Eberle

INTRODUCTION

Since the introduction of the original cementing technique introduced by Charnley in 1960, the use of polymethylmethacrylate (PMMA) for cementing the femoral component has become one of the most frequent and successful procedures in orthopedic surgery. The early results of Charnley have become the "gold standard" by which the results of modern component designs and fixation methods are compared.

IMPLANT DESCRIPTION

The SP-II® femoral component was introduced in 1982 as the first anatomical shaped femoral component with a "built-in" neck anteversion (Link Orthopaedics, GmbH & Co., Hamburg, Germany) (Fig. 1). It is made out of a cobalt-chrome-molybdenum-alloy with a satin finish (Ra = 6µ). The implant has a collar to guarantee a reproducible position in the medullary canal. The stems shape was derived from a thorough analysis of a sample of cadaveric femora and the intention is to avoid any metal bone contact and an even distributed cement mantle with a uniform thickness. To allow adaptation to different formats of the femur the stem is available in up to 6 sizes and in 3 lengths of 130, 150 respectively 170 mm. For the use in big scaled anatomies the stem is also available with a 10mm longer Morse taper of 12/14mm. To allow adaptation to different CCD-angles the stem is available with 3 angles of 135°, 126° and 117°.

PRINCIPLES OF SUCCESSFUL CEMENTED THA

It is not only the quality of the implant that influences the survival, but there are a few other parameters that have to be addressed. In 1978, Lee, et al, put their focus on an exact preparation of the bone bed and recommended the use of pressurization of the cement to obtain a better interdigitation between bone and cement [1]. This also included the recommendation for the use of low viscosity cement to improve the quality of the bone cement interface. Further improvements of the cementing techniques were developed by Harris et al. [2]. In Germany, propagation of what we name today as "third generation cementing technique" was strongly influenced by Draenert [3]. Many concepts on why and how an early failure of the bone cement inter-

The Lubinus Clinicum
Steenbeker Weg 25
24106 Kiel, Germany

*Relazione presentata in occasione dell'87° Congresso Nazionale della SIOT svoltosi a Venezia dal 20 al 24 Ottobre 2002.

Fig. 1. SP-II Femoral Component for Cemented Total Hip Arthroplasty (Link Orthopaedics, GmbH & Co., Hamburg, Germany).

face happens and how related mistakes of the surgeon can be avoided were communicated at this time. From the pioneering work of these surgeons, the principle for superior results of cementation of the femoral component is currently employed at our facility and include:

1) The Integrity of the Cement Mantle
The goal of cementation is an evenly distributed circumferential cement mantel with a minimum thickness of 1.0 mm.

2) The Quality of the Bone-to-Cement Interface
Following reaming and component broaching, 2-4 mm of cancellous bone is left intact for optimum cement interdigitation. To prevent bleeding out of the bone during the cement introduction and curing, a two drainage system is used, one at the tip of the greater trochanter, the other at the cement restrictor.

3) The Physical Properties of the Cement
Third generation cement techniques (pre-cooled acrylic cement, mixing device under vacuum, cement restrictor, pulse lavage), results in a cement with superior mechanical properties, which include compressive, tensile and fatigue strength.

4) The Wear Resistance of the Bearing
The use of various materials in combination as a bearing surface is of paramount importance regarding osteolysis and subsequent aseptic loosening and failure of the implanted components.

5) The Quality of the Hip's Biomechanical Reconstruction
To optimize lever arm geometry selecting a proper center of rotation and a stem with an individually optimized offset is essential for the longevity of the THA composite.

METHODOLOGY OF CEMENTED THA – THE LUBINUS CLINICUM

The goal of cemented THA is to create an evenly distributed cement mantle with a minimum thickness of no less than 1.0 mm for the anatomically shaped SP-II femoral component. This is achieved by "third generation" cement technique. Third generation cement technique incorporates three separate aspects: 1) femoral canal preparation and lavage, 2) a mixing device in which the precooled monomer and polymer are united and mixed under vacuum and, 3) cementation under pressure and vacuum (Fig. 2A).
After performing the femoral head and neck resection as determined by pre-operative review and planning, and acetabular component implantation, the proximal aspect of the femoral canal is opened using a hollow chisel and the conical shaped bone fragment is retained for use as a distal femoral cement restrictor (to aid in cement pressurization). Next, an undersized femoral broach is introduced into the femur with a wedge mallet while controlling for anteversion. A sequential series of broaches are used until the appropriate depth and firm broach seating is obtained. With the final broach in place, the insertion handle is replaced with a front-cutting reamer which is used to mill the proximal aspect of the femur to correctly accept the component collar.

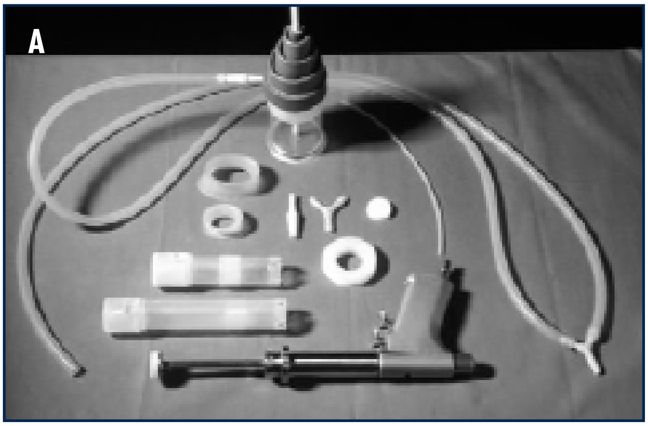

Fig. 2. Cement mixing and delivery apparatus (A), and placement of femoral suction screws for maintaining a dry femoral canal prior to, and during, introduction of cement (B).

Following removal of the final broach and lavage, two 4.5 mm holes in the femur are prepared at the tip of the greater trochanter and near the base of the prepared femoral canal (Fig. 2B). The retained conical bone fragment is inserted into the prepared canal and, following a trial reduction with the preplanned femoral component, a cannulated screw is inserted into the drill-hole in the greater trochanter. A thin plastic tube is now guided through the hole in the posterior femoral wall and a mild vacuum of 0.2 BAR is applied to both ports while performing a thorough jet pulsed lavage of the prepared femoral canal. On the back table, the cooled monomer and polymer are united in the mixing chamber. To reduce voids in the cement during mixing, a vacuum of 0.9 BAR is applied to remove all visible traces of air in the mixture. Fifteen seconds following the application of the vacuum mixing begins the mixing begins. One minute after the start of cement mixing, the vacuum tube is detached and the cartouche is inserted into a manual cement gun. Five and one half minutes following the initiation of the mixing procedure, and after the final femoral lavage, the cement is inserted into the prepared femoral canal.
The proximal aspect of the femoral canal is sealed using a reusable rubber seal which aids in the pressurization process. The distal drain port is extracted but the proximal suction port remains during component insertion.
Visual inspection of the proximal femur should reveal no blood in the bone-to-cement interface. The insertion of the femoral component follows the central line of the prepared canal and the component is guided utilizing the viscoelastic force of the cement. The final component position is guided by the correlation between the component collar and the prepared proximal aspect of the femur.

PRE-OPERATIVE PLANNING AND RESTORATION OF HIP BIOMECHANICS

Restoration of biomechanics in patients with primary THA is imperative to produce good functional outcome. A prorospective study was conducted to evaluate a preoperative planning program that has been used in our hospital since 1993 and which serves to evaluate biomechanics.
Five-hundred patients (168 male and 332 female patients) with primary osteoarthritis of one hip and a healthy contralateral hip were planned preoperatively using a *Computer Assisted Pre-operative Planning System* (CAPS) (Fi. 3). Height and offset of the center-of-rotation, leg length difference, muscle lever arm were compared pre- and post-operatively (Figs. 4A-D). Statistics were performed using the Chi-Square test and all patients were planned and operated on by the senior author (PL). The outcome was graphically evaluated on the postoperative radiographs. All patients received the same type of femoral component and either a cementless or a cemented cup depending on the quality of bone.
All patients were operated by the senior author (PL) using a

Fig. 3. Pre-Operative Total Hip Arthroplasty Digital Planning System

posterolateral approach. Average age in the patient group was 69.4 years. Complications at time of latest f/u included 5 patients with periarticular ossifications, 10 patients with dislocations (average time 1.2 years after surgery), 1 patient with a revision for subfascial hematoma and 1 deep infection. Biomechanical evaluation showed reduction of height and offset of the center-of-rotation of the operated hip as compared to the opposite side (both non-significant), but also an increase in the muscle lever arm and a moderate decrease in the leg length difference. Correct prediction of the implants using CAPS was possible in 98 % of the femoral components.

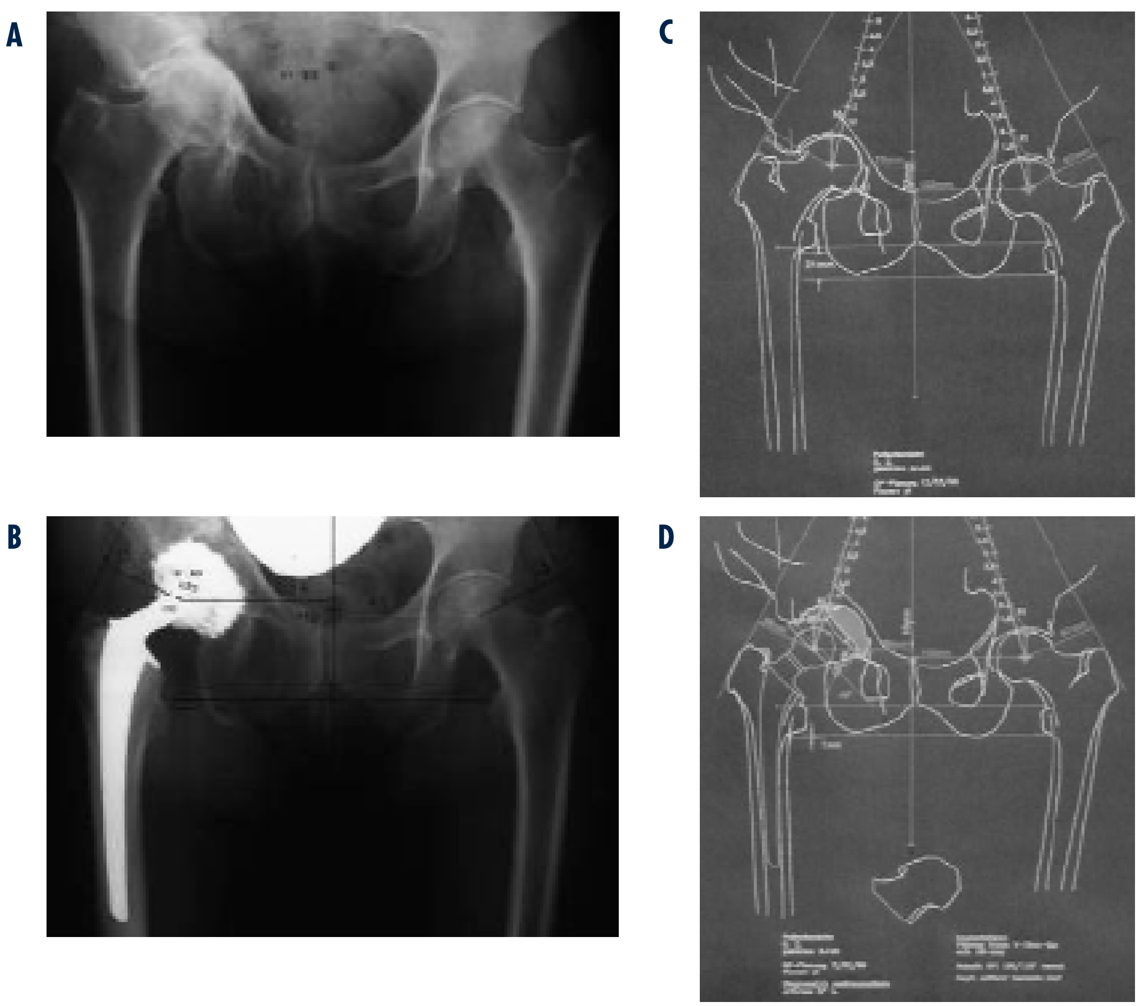

Fig. 4 (A-B). Pre- and post-operative radiographs and corresponding planning output.

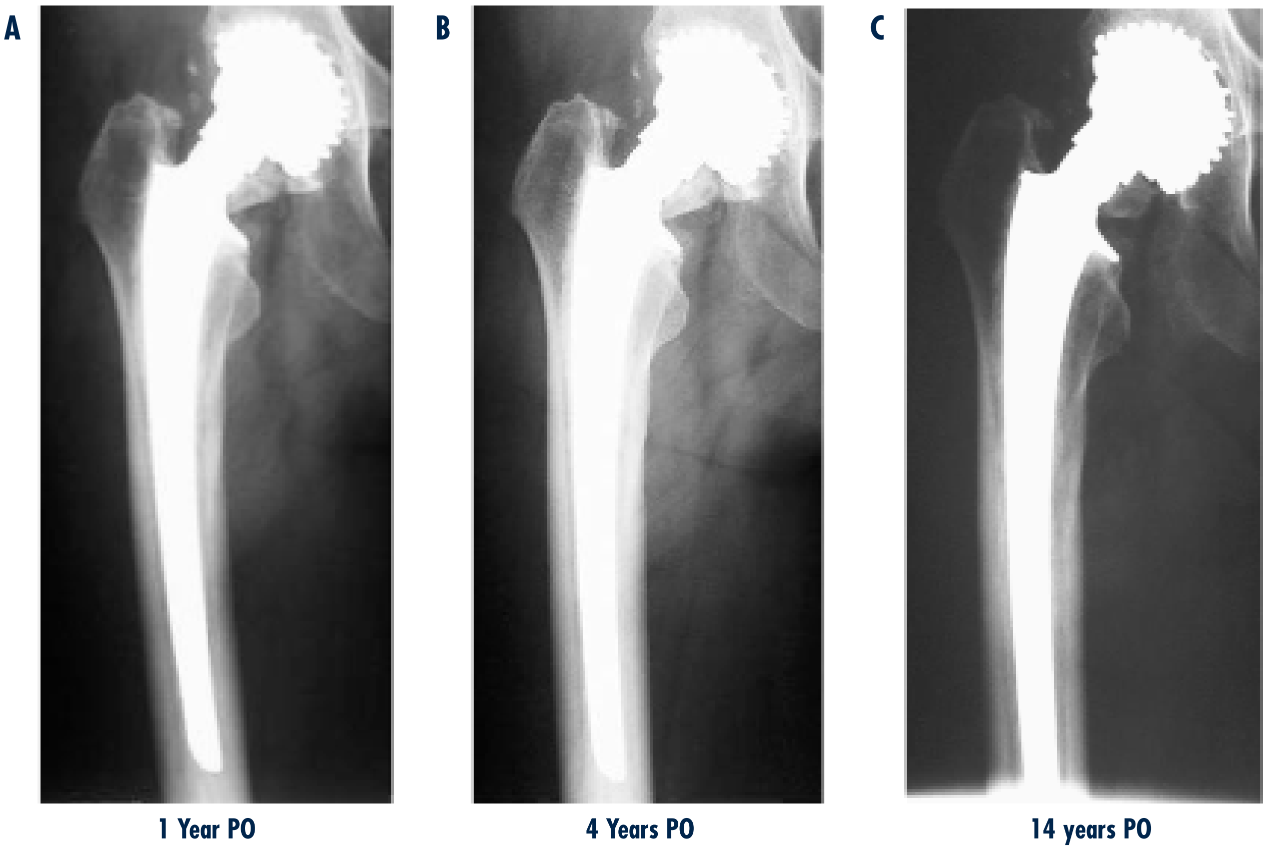

Fig. 5 (A-C). Well functioning right THA (SP-II cemented femoral component) performed in 1988 with postoperative radiographic follow-up at 1 year (1989) 4 years (1992) and at 14 years (2002).

Our prospective study shows good restoration of biomechanics in all of the 4 different biomechanical parameters. Due to its good predictive values our CAPS helps us to control quality and order our implants online from our manufacturer, which keeps our stock cost low. Our postoperative complication rate compares favourable to other studies.

LONG-TERM EXPERIENCE WITH THE SP-II FEMORAL COMPONENT

Between May and December of 1988, 100 consecutive THA candidates were implanted with the SP-II femoral component (Waldemar Link GmbH & Co, Hamburg, Germany). All THAs were performed at a single institution. Of the 100 patients, 26 were deceased and 4 were lost to follow-up, leaving 70 hips (average follow-up: 158 months, range: 144 months-168 months), for retrospective review. All patients were evaluated using a modified Harris Hip Score (HHS). Serial radiographs were evaluated pre-operatively, and post-operatively at 3 months and at time of last follow-up.

The average age for patients was 71.2 years, range 41years to 85 years. Average pre-operative HHS was 44, which improved to 79.2 (151 months). There were 4 early and 3 late infections, and there were 5 cases of post-operative dislocation (3 required cup revision). There were 4 femoral component revisions: 1 (1%) were due to infection; 2 (2%) were due to aseptic loosening; 1 (1%) due to recurrent dislocation. At the most recent follow-up, there was no reported thigh pain. In all other cases reviewed, the bone-to-cement and cement-to-prosthesis interfaces were intact and without signs of debonding or component loosening (Figs. 5A-5C). Heterotopic ossification was graded using the classification defined by Brooker [4] and was observed in 21 hips (21%) (I-9, II-5, III-5, IV-2). Osteolysis occurred in 19 hips and was observed in the following Gruen Zones: I-6, II-4, III-4, IV-5, V-3, VI-0, VII-6.

The SP-II femoral component has good long-term clinical and radiographic results that are comparable to other published studies of the Charnley and SP-II femoral components [5 6]. Including revisions for infection, the Kaplan-Meier survival rate, after 158 months, of the femoral component was 95%. These results parallel the excellent results of 18,824 SP-II (96.7% @ 10 years) and 38,769 Charnley femoral components (92.0% @ 10 years) referenced in the recent Swedish National Hip Registry reported by Malchau, et al [5].

CONCLUSION

From these long-term results (personal and the Swedish Hip Registry) the authors believe that the continuation of use of the SP-II for cemented THA is clearly justified and, when implanted following the reviewed principles, will yield optimum outcomes both clinically and radiographically.

REFERENCES

1. Lee AJC, Ling RSM, Vangala SS. *Some clinically relevant variables affecting the mechanical behaviour of bone cement*. Arch Oarthop Traumat Surg 1978;92:1-18.
2. Oh I, Bourne RB, Harris WH. *The femoral cement compactor. An improvement in cementing technique in total hip replacement*. J Bone Joint Surg 1983;65A:1335-8.
3. Draenert K, Draenert Y. *Moderne zementierungstechniken in der endoprothetik und ihre technischen voraussetzungen*. Jahbuch der Orthopädie. Zülpich (Germany): Biermann Verlag 1989:117-31.
4. Brooker AF, Bowerman JW, Robinson RA, Riley LH Jr. *Ectopic ossification following total hip replacement. Incidence and a method of classification*. J Bone Joint Surg 1973;55A:1629-32.
5. Charnley J. *Low friction arthroplasty of the hip*. Berlin: Springer 1979.
6. Wroblewski BM, Siney PA, Fleming PD. Charnley low-frictional torque arthroplasty of the hip. 20-to-30 year results. J Bone Joint Surg 1999;81B:427-30.
7. Malchau H, Herberts P, Garallick G, Söderman P, Eisler T. *Prognosis of total hip replacement: Update of results and risk-ratio analysis for revision and re-revision from the Swedish national hip arthroplasty register 1979-2000*. 69th Annual Meeting of the American Academy of Orthopaedic Surgeons [Scientific Exhibit], Dallas, Texas, USA, February 13-17, 2002.