Revision Total Hip Arthroplasty: The Femoral Component

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Abstract

The initial results with cemented femoral revision stems were disappointing, with high early loosening rates. The application of second-generation cementing techniques improved results markedly, with loosening rates of 10% at 10 years in a number of series. Bone quality and patient age also appear to be important factors in predicting the success with a cemented revision stem. The use of a long stem is not necessary to obtain these improved results. On the basis of early reports, a recently described technique in which a revision stem is cemented into impacted cancellous allograft appears promising. Results with proximally coated uncemented revision stems have been variable, with failure rates of 4% to 10% reported at only 2 to 4 years. Initial stability must be obtained if proximal coating is to be utilized. Extensively coated revision stems provide initial stability through an interference fit between the porous coating and the diaphysis. With this technique, 10-year survival rates of 90% have been achieved, and the clinical results appear to be equivalent to those obtained with cemented revision stems and modern cementing techniques. Diaphyseal fixation has also been achieved without porous coating, either with modular revision stems or with long, textured titanium stems. Isolated early reports with such stems have been promising, but 10-year results are not yet available.

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The results of revision total hip arthroplasty (THA) are difficult to interpret for a number of reasons. There is no standard method of reporting results. Some authors report re-revision rates, while others report rates of radiographic loosening and still others report the number of stems that are loose and symptomatic. The number of cases reported in revision series is much lower than that in corresponding series dealing with primary THA, and the patients are more heterogeneous because of their past history of one or more hip operations and the variability of the corresponding bone and soft-tissue loss. Finally, results change as techniques evolve, and certain techniques have different outcomes depending on whether they are used on the femoral side or the acetabular side. For this reason, it is easier to interpret results by focusing on the technique involved and the time frame of the report and by reporting acetabular and femoral results separately. This article will focus specifically on the results of cemented and cementless femoral revision.

Cemented Femoral Revision

Early Results

The initial results with revision THA were poor. Direct application of the primary cementing techniques of the 1970s to femoral revision yielded poor results, which were often evident in the short term. Hunter et al[1] reported a dismal 32% infection rate after 140 revision procedures, and resection arthroplasty was eventually necessary in 22% of cases. Amstutz et al[2] also reported discouraging results in 66 patients at a mean follow-up of 2.1 years. The re-revision rate was 9%, and loosening was expected in an additional 29% of cases on the basis of radiologic changes. They also noted an alarming rate of complications, including femoral fracture in 6.0% of cases, dislocation in 10.6%, and infection in 1.5%.

Three subsequent studies reported more extensive experience with

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cemented revision stems. Pellicci et al,[3] Kavanagh et al,[4] and Callaghan et al[5] reported re-revision rates ranging from 4.3% to 6.0% after mean follow-up intervals of 3.4 to 4.5 years. The incidence of radiographic loosening ranged from 12% to 44% (Table 1). When Pellicci et al[6] examined their original group of patients an average of 8.1 years after revision, the re-revision and radiologic loosening rates had more than doubled—-from 5.4% to 19% and from 13.6% to 29%, respectively. Kavanagh et al[7] reported a similar experience; at the 10-year follow-up of their patients they found that 64% of stems either had been revised or were loose. The probability of revision increased from 18% at 3 years to 39% at 11 years. Important factors in predicting success or failure included the quality of the bone-cement interface, bone quality, and patient age.

Similarly, Kilgus et al[8] reported a 5-year failure rate of 9% with good cementing technique but a threefold higher rate with inadequate cementing. They confirmed that age was a factor; patients under 55 had a 33% failure rate, compared with 10% in those over 65. When these two variables were combined, the failure rate with good cementing technique in patients over 65 was 0%.

In a recent report, Retpen and Jensen[9] examined predictive factors of success in cemented revision stems and confirmed that age and use of optimal cementing technique are predictors for success with a cemented revision stem. They also reported that long stems were associated with a higher success rate.

Turner et al[10] also reported relatively good results with cemented long stems. At an average of 7 years postoperatively, the re-revision and pending revision rates were only 5%.

These studies contributed to the popularity of long-stem cemented revisions in the 1980s. However, difficulty with revising stems when the prosthesis and cement extend beyond the isthmus has dampened the initial enthusiasm for cemented long revision stems.

Collis[11] recently reported on 110 cemented femoral revisions, of which only 3.6% required re-revision at follow-up averaging 4.6 years. Utilizing survivorship analysis with stem revision as the end point, a 5-year survival of 89% and a 10-year stem survival of 84% were predicted. Long stems were used in only 10% of cases. In subsequent studies in which modern cementing techniques were used, comparable or even better results were obtained, even though long stems were used in a very small number of cases.

Recent Results

The preceding compilation of results indicates that the introduction of second-generation cementing

Table 1
Results of Cemented Femoral Revision

Authors	No. of Hips	Follow-up, yr	Good / Excellent Results, %	Re-revision Rate, %	Radiographic Evidence of Femoral Loosening, %
Amstutz et al[2]	66	2.1 (mean)	. . .	9.0	29.0
Pellicci et al[3]	110	3.4 (mean)	60	5.4	13.6
Pellicci et al[6]	99	8.1 (mean)	63	19.0	29.0
Kavanagh et al[4]	166	4.5 (mean)	52	6.0	44.0
Kavanagh et al[7]	210	10.0 (mean)	. . .	30.0	. . .
Callaghan et al[5]*	139	3.6 (mean)	66	4.3	12.0
Rubash and Harris[12]*	43	6.2 (mean)	72	4.0	11.0
Estok and Harris[13]*	38	11.7 (mean)	58	10.5	10.5
Katz et al[17]	82	10.0 (minimum)	. . .	6.0	10.0
Izquierdo and Northmore-Ball[15]	112	6.5 (mean)	. . .	3.6	7.7
Huo and Salvati[16]	113	4.1 (mean)	83	3.0	16.0
Collis[11]*	110	4.6 (mean)	93	3.6	5.0
Kilgus et al[8]	92	5.1 (mean)	. . .	9.0†	. . .
Pierson and Harris[18]*	29	8.5 (mean)	86	6.9	3.8

*A second-generation cementing technique was used.
†Combined revision plus loosening rate.

techniques and modifications in implant design have significantly improved the results with cemented stems in revision THA. The use of a medullary plug, pulsatile lavage irrigation, and the delivery of cement in the doughy phase by a cement gun with pressurization have clearly improved the durability of cemented stems in primary surgery.

Improved results with these techniques in revision were observed by Rubash and Harris[12] in their series of 43 hips. After an average postoperative surveillance period of 6 years, only 1 hip (2.3%) required re-revision, and an additional 6 hips (14%) appeared loose radiographically. At further follow-up averaging 11.7 years, 4 of 38 hips (10.5%) had been revised, and another 4 (10.5%) showed radiographic evidence of loosening.[13] The 15-year follow-up of this cohort revealed an 18.6% revision rate.[14]

A number of other authors have reported analogous results with improvement in cementing technique.[15-18] For example, a 10-year follow-up study by Katz et al[17] reported a re-revision rate of only 6%.

Pierson and Harris[18] reviewed the use of second-generation cementing techniques in revisions in 29 patients in whom femoral osteolysis was associated with a primary cemented stem. After an average follow-up interval of 8.5 years, osteolysis recurred in only 2 patients (6.9%), and 25 components (86%) remained well fixed. These findings indicate that lysis is not an idiosyncratic response to polymethylmethacrylate and that its presence is not a contraindication to the use of cement in a revision stem.

While improved cementing techniques have lowered the failure rate of revision stems to approximately 10% at 10 years and 15% to 20% at 15 years, the results do not approach those obtained with primary cemented femoral stems, for which 10-year failure rates less than 5% have been reported. These differences have been attributed to the limited ability to obtain macrointerlock of the polymethylmethacrylate with cancellous bone in femoral-stem revisions.

Dohmae et al[19] found a dramatic reduction in the resistance to shear forces at the bone-cement interface in laboratory simulations of femoral revision. In their study, a simulated first revision underwent a reduction in interface shear strength to 20.6% of its primary strength, and a second revision had only 6.8% of the primary strength.

These findings are consistent with those of Barrack et al,[20] who evaluated new cementing techniques on the basis of the radiographic appearance immediately postoperatively. In their classification, complete filling of the medullary cavity by cement (a so-called white-out at the bone cement interface) is designated grade A; slight radiolucency of the bone-cement interface, grade B; radiolucency involving up to 99% of the bone-cement interface, grade C; and radiolucency at the bone-cement interface of 100% in any projection or failure to fill the canal to prevent or correct abutment of the stem against the cortex, grade D. Barrack et al found grade A or B cementing in 100% of the primary procedures in their series, compared with only 60% in the revision cases reported by Estok et al.[13] This difficulty with cementing may ultimately limit the results that can be expected with cemented revision stems given the current state of technology (Fig. 1).

Two novel approaches have recently been described for cemented femoral revision. The first involves the unusual circumstance of a well-fixed stem and an intact cement mantle and bone-cement interface. Usually, stem removal is necessary for exposure to revise an acetabulum and/or adjust neck length. In con-

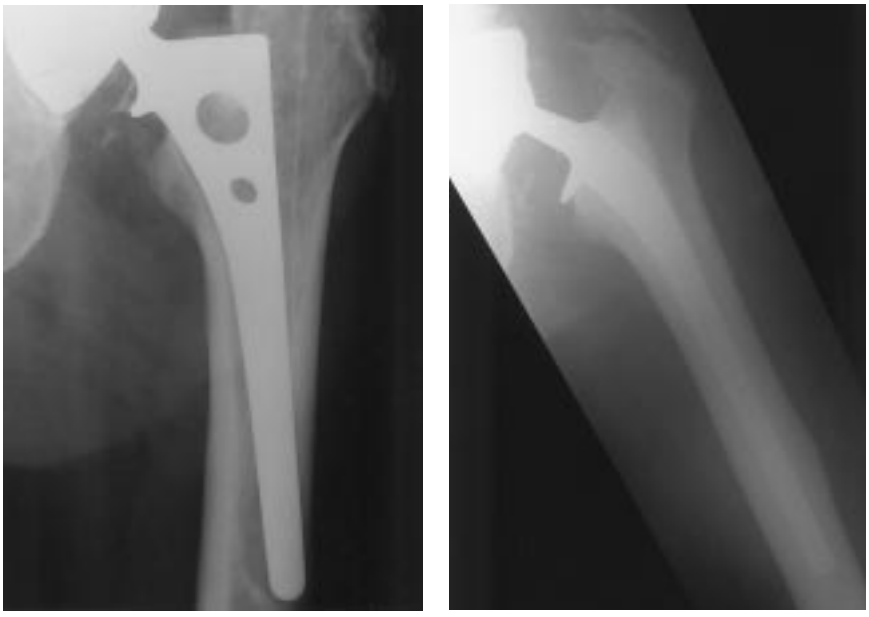

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Fig. 1 **A,** Preoperative radiograph of a loose uncemented femoral stem. **B,** Revision with grade A cementing.

trast, with the cement-within-cement technique, the component is tapped out, leaving the mantle intact, and is then recemented into the mantle. Lieberman et al[21] have reported 19 such cases in which this technique was used and found no stem loosening after 5 years.

The second approach involves the more common circumstance of proximal osteolysis and bone loss where it is uncertain whether the remaining bone can support a cement mantle. Gie et al[22] have described the impacted grafting technique, which has the objective of restoring the deficient proximal femoral bone stock. The surgical technique includes thorough debridement of the proximal femur and medullary canal to remove all residual cement and membrane. Any proximal femoral cortical defects are covered with bone graft and/or mesh, and the entire proximal femur is packed with morcellated cancellous allograft bone. A channel is then impacted through the graft with use of a tapered wedge broach. The distal canal is occluded, pressurized bone cement is applied, and a polished collarless stem is inserted (Fig. 2). Short-term results with this technique reported by Gie et al[22] have been promising, with reconstitution of proximal bone often occurring; however, there was an occasional shaft fracture, which is a concern.

Elting[23] performed 100 femoral revisions utilizing this method and reported similarly optimistic results at the 2-year follow-up of 31 cases. Results must be considered preliminary at present, however, since follow-up is short.

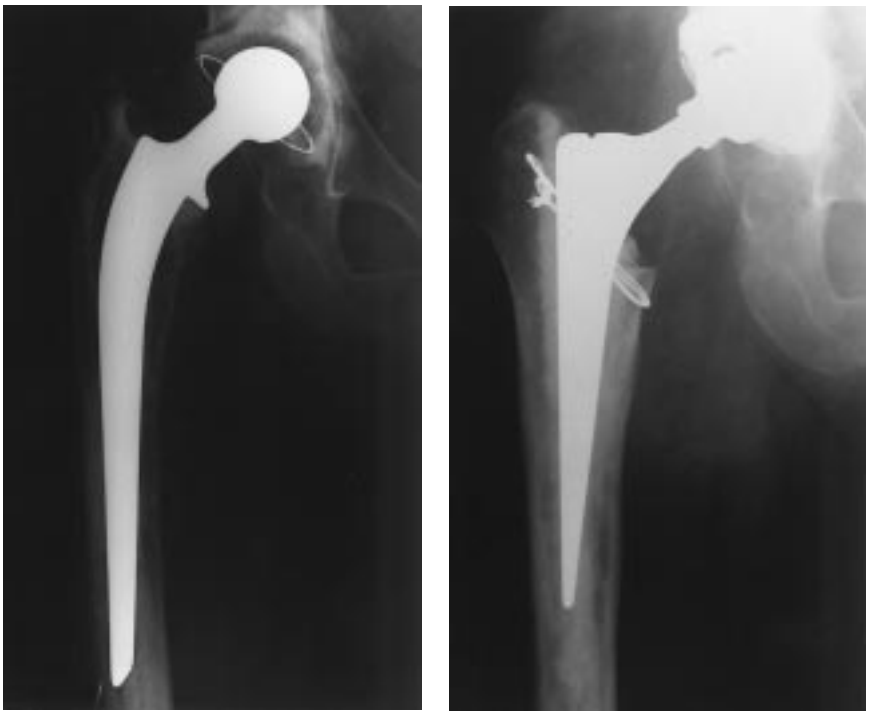

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Fig. 2 **A,** Preoperative radiograph demonstrates proximal femoral bone loss. **B,** Postoperative radiograph shows polished collarless stem inserted with impacted grafting technique.

Cementless Femoral Revision

The use of cementless stems in revision THA gained popularity as a result of the initial poor outcomes with cemented revision stems. However, in the late 1980s this initial enthusiasm was tempered because of a number of studies that analyzed short-term results of cementless revisions[24-27] (Table 2). Failure rates of 4% to 9.5% were noted at follow-up intervals of 1 to 4 years. These results were marginally better than those in early reports on cemented revision stems, but were far inferior to the results with revision stems inserted with optimal cementing technique.

In addition, certain design features of uncemented revision stems have not had a good track record, in particular, proximally coated collarless stems. Malkani et al[28] reported an 8% rate of early failure, and another 20% of patients had painful subsidence 2 to 5 years after implantation. The simple addition of a collar to a proximally coated stem did not resolve these problems. Trousdale and Morrey,[29] Rivero et al,[30] and Hussamy and Lachiewicz[31] reported re-revision rates as high as 10% and subsidence rates ranging from 30% to 56% with a collared femoral component (BIAS, Zimmer, Warsaw, Ind) after an average follow-up interval of 4.2 to 4.5 years (Table 2). Recently, Woolson et al[32] reported on proximally coated BIAS and Harris-Galante (Zimmer, Warsaw, Ind) prostheses for femoral revision. At an average 5.3-year follow-up, 16% had been re-revised, 50% had subsided, and the results with 22% were clinically rated as poor.

The high rates of subsidence observed in many series made it clear that proximal coating alone is not adequate to ensure initial stabil-

Table 2
Results of Cementless Femoral Revision

Authors	Component*	No. of Hips	Follow-up, yr	Results
Hedley et al[24]	PCA	61	1 (minimum)	9.5% femoral loosening
Engh et al[25]	AML	127	4 (mean)	4.0% femoral loosening
Gustilo and Pasternak[26]	BIAS	57	2.8 (mean)	4.0% femoral revision
Harris et al[27]	Harris-Galante	23	2 (minimum)	4.0% femoral loosening
Malkani et al[28]	Omnifit	74	2-5	8% failure, 20% painful subsidence
Trousdale and Morrey[29]	BIAS	96	4.2 (mean)	10% re-revision, 37% subsidence >2 mm
Rivero et al[30]	BIAS	48	4.2 (mean)	4% re-revision, 31% subsidence ≥4 mm
Hussamy and Lachiewicz[31]	BIAS	43	4.5 (mean)	0% re-revision, 32% subsidence (mean, 8 mm)
Dorr[33]	APR (collarless)	100	. . .	50% re-revision, 50% subsidence
	APR (collared)	75	. . .	<1% re-revision, 0% subsidence
McCarthy et al[34]	S-ROM	133	5 (mean)	1.5% re-revision, 4% subsidence
Lawrence et al[35]	AML	174	8.4 (mean)	5.7% re-revision, 90.6% survivorship (10 yr)
Paprosky et al[36]	Solution	311	5.8 (mean)	6% re-revision

*Proprietary names and manufacturers: AML, DePuy, Warsaw, Ind; APR, Intermedics, Austin, Texas; BIAS, Zimmer, Warsaw, Ind; Harris-Galante, Zimmer; Omnifit, Osteonics, Allendale, NJ; PCA, Howmedica, Rutherford, NJ; Solution, DePuy; S-ROM, Joint Medical Products, Stamford, Conn.

ity in many cases. This led others to redesign the geometry of the femoral stem. In reviewing his experience with a double-wedge collared design, Dorr[33] reported that only 1 of 75 revision implants subsided, compared with a 50% subsidence rate with a previous design with geometry that did not impart initial stability.

One approach to achieving stability with proximal coating is through the use of a modular stem, such as the S-ROM prosthesis (Joint Medical Products, Stamford, Conn). This design allows a porous-coated metaphyseal segment to be press-fitted proximally and mated with a slotted diaphyseal segment, which can provide initial stability through distal fixation. After an average follow-up of 5 years, McCarthy et al[34] found a re-revision rate of only 1.5% and a subsidence rate of only 4% with this design, which represented an improvement compared with other proximally coated designs available at the time. While the potential for wear and corrosion products from these modular components remains a concern, clinical experience has yet to demonstrate that this is a significant problem.

Another approach to achieving initial stability consistently is to use an extensively coated prosthesis. The longest-term results reported in the literature to date with uncemented revision femoral stems are those for such a prosthesis. Lawrence et al[35] recently reported on 174 cementless revisions performed with the AML prosthesis (Depuy, Warsaw, Ind). The postoperative surveillance averaged 8.4 years (range, 5 to 13 years). The re-revision rate was 5.7%, and survivorship at 10 years was calculated as 90.6%. Their results are therefore equivalent to the reported survival of femoral revisions performed with contemporary cementing techniques (Fig. 3). As with cemented revisions, they found a correlation between the clinical and radiologic results and the extent of bone-stock damage. With stem revision taken as the end point for failure, patients with mild and moderate bone damage had success rates of 100% and 97.8%, respectively, but the group with severe bone damage had a rate of only 76.9%.

Paprosky et al[36] have also reported results with extensively coated revision stems. In a series of 311 cases with an average follow-up interval of 5.8 years, only 6% of the stems had to be re-revised. Moreover, the use of extensively coated 8- or 10-inch stems was clinically successful even in the face of significant proximal bone loss.

Distal porous coating is not the only strategy for achieving initial stability or successful clinical results in the face of significant proximal femoral bone loss. Wagner[37] has reported success with a long, fluted titanium-alloy stem that is textured (corundum-blasted) rather than porous-coated. Immediate stability is achieved through diaphyseal fixation; porous coating and distal ingrowth are not utilized. Wagner reported proximal bone regeneration with this implant as well, but

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Fig. 3 **A,** Preoperative radiograph of a loose cemented stem. **B,** Postoperative radiograph of revision with use of an extensively coated stem.

long-term results in a large series of patients have yet to be reported.

The approaches advocated by McCarthy et al,[34] Lawrence et al,[35] Paprosky et al,[36] and Wagner[37] have in common the goal of obtaining immediate tight fit and mechanical stability, which is consistently achieved through diaphyseal fixation with or without porous coating.

Summary

The results with femoral stem revision, while improved in recent years, are not as good as those with primary stems in THA. Stem loosening rates as low as 10% have been achieved at 10 years with both cemented and cementless techniques. Modern cementing achieves a good radiographic appearance in a much lower percentage of revision cases than primary cases due to the relative lack of cancellous bone with which to achieve cement intrusion. Cementing a long stem is generally to be avoided because of the difficulty of applying current cementing techniques with a long stem as well as the extreme difficulty of revising a stem cemented past the isthmus. There is consensus that cemented revision stems are best suited for older patients with adequate bone quality.

Proximally coated stems have been generally inadequate in the revision situation. Immediate stability must be obtained, and this has been most consistently achieved with an extensively porous-coated stem. The only large series of cementless revisions with results beyond 10 years involves such an implant. Extensively coated stems are particularly applicable in younger patients and those with significant proximal bone loss. The use of cement in conjunction with impacted cancellous grafting appears to hold promise as a stem-revision technique when there is substantial proximal bone loss; in that setting, results of both cemented and cementless femoral revision have been suboptimal.

References

1. Hunter GA, Welsh RP, Cameron HU, et al: The results of revision of total hip arthroplasty. *J Bone Joint Surg Br* 1979;61:419-421.
2. Amstutz HC, Ma SM, Jinnah RH, et al: Revision of aseptic loose total hip arthroplasties. *Clin Orthop* 1982;170:21-33.
3. Pellicci PM, Wilson PD Jr, Sledge CB, et al: Revision total hip arthroplasty. *Clin Orthop* 1982;170:34-41.
4. Kavanagh BF, Ilstrup DM, Fitzgerald RH Jr: Revision total hip arthroplasty. *J Bone Joint Surg Am* 1985;67:517-526.
5. Callaghan JJ, Salvati EA, Pellicci PM, et al: Results of revision for mechanical failure after cemented total hip replacement, 1979 to 1982: A two to five-year follow-up. *J Bone Joint Surg Am* 1985;67:1074-1085.
6. Pellicci PM, Wilson PD Jr, Sledge CB, et al: Long-term results of revision total hip replacement: A follow-up report. *J Bone Joint Surg Am* 1985;67:513-516.
7. Kavanagh BF, Wallrichs S, Ilstrup D, et al: Ten year follow up of cemented revision total hip replacement. *Orthop Trans* 1993;17:943.
8. Kilgus DJ, Luetzow W, Tipton J, et al: Factors affecting the outcome of

femoral component revision in total hip arthroplasty. *Orthop Trans* 1993;17: 966-967.

9. Retpen JB, Jensen JS: Risk factors for recurrent aseptic loosening of the femoral component after cemented revision. *J Arthroplasty* 1993;8:471-478.
10. Turner RH, Mattingly DA, Scheller A: Femoral revision total hip arthroplasty using a long-stem femoral component: Clinical and radiographic analysis. *J Arthroplasty* 1987;2:247-258.
11. Collis DK: Revision total hip replacement with cement. *Semin Arthroplasty* 1993;4:38-49.
12. Rubash HE, Harris WH: Revision of nonseptic, loose, cemented femoral components using modern cementing techniques. *J Arthroplasty* 1988;3:241-248.
13. Estok DM II, Harris WH: Long-term results of cemented femoral revision surgery using second-generation techniques: An average 11.7-year follow-up evaluation. *Clin Orthop* 1994;299:190-202.
14. Mulroy WF, Estok DM II, Harris WH: Fifteen year results of cemented femoral revisions using second-generation cementing technique. Presented at the 61st Annual Meeting of the American Academy of Orthopaedic Surgeons, New Orleans, February 28, 1994.
15. Izquierdo RJ, Northmore-Ball MD: Long-term results of revision hip arthroplasty: Survival analysis with special reference to the femoral component. *J Bone Joint Surg Br* 1994;76:34-39.
16. Huo MH, Salvati EA: Revision total hip replacement using cement. *Techniques Orthop* 1993;7:58-64.
17. Katz RP, Callaghan JJ, Sullivan PM, et al: Cemented revision total hip arthroplasty using contemporary techniques: A minimum ten year follow-up study. *J Arthroplasty* 1994;9:103.
18. Pierson JL, Harris WH: Cemented revision for femoral osteolysis in cemented arthroplasties: Results in 29 hips after a mean 8.5-year follow-up. *J Bone Joint Surg Br* 1994;76:40-44.
19. Dohmae Y, Bechtold JE, Sherman RE, et al: Reduction in cement-bone interface shear strength between primary and revision arthroplasty. *Clin Orthop* 1988;236:214-220.
20. Barrack RL, Mulroy RD Jr, Harris WH: Improved cementing techniques and femoral component loosening in young patients with hip arthroplasty: A 12-year radiographic review. *J Bone Joint Surg Br* 1992;74:385-389.
21. Lieberman JR, Moeckel BH, Evans BG, et al: Cement-within-cement revision hip arthroplasty. *J Bone Joint Surg Br* 1993;75:869-871.
22. Gie GA, Linder L, Ling RSM, et al: Impacted cancellous allografts and cement for revision total hip arthroplasty. *J Bone Joint Surg Br* 1993;75: 14-21.
23. Elting JJ: Exchange femoral arthroplasty with compacted morselized bank bone and cemented collarless polished taper stem. Presented at the Third Annual Meeting of the Association for Arthritic Hip and Knee Society, Dallas, November 12-14, 1993.
24. Hedley AK, Gruen TA, Ruoff DP: Revision of failed total hip arthroplasties with uncemented porous-coated anatomic components. *Clin Orthop* 1988;235:75-90.
25. Engh CA, Glassman, AH, Griffin WL, et al: Results of cementless revision for failed cemented total hip arthroplasty. *Clin Orthop* 1988;235:91-110
26. Gustilo RB, Pasternak HS: Revision total hip arthroplasty with titanium ingrowth prosthesis and bone grafting for failed cemented femoral component loosening. *Clin Orthop* 1988;235:111-119.
27. Harris WH, Krushell RJ, Galante JO: Results of cementless revisions of total hip arthroplasties using the Harris-Galante prosthesis. *Clin Orthop* 1988;235:120-126.
28. Malkani AL, Lewallen DG, Cabanela ME: Two to five year follow-up of femoral component revisions using an uncemented, proximally-coated, chrome cobalt, long-stem, curved prosthesis. *Orthop Trans* 1993;17:940-941.
29. Trousdale RT, Morrey BF: Uncemented femoral revision of total hip arthroplasty. *Orthop Trans* 1993;17: 964-965.
30. Rivero D, Jacobs JJ, Galante JO, et al: Revision cementless total hip arthroplasty: Two to five year results. *Orthop Trans* 1993;17:171.
31. Hussamy O, Lachiewicz P: A prospective study of revision total hip arthroplasty using the BIAS femoral component. *Orthop Trans* 1993; 17:968.
32. Woolson ST, Delaney TJ: Failure of proximally porous-coated femoral prosthesis in revision total hip replacement. Presented at the 61st Annual Meeting of the American Academy of Orthopaedic Surgeons, New Orleans, February 24, 1994.
33. Dorr LD: Results of noncemented revision. *Semin Arthroplasty* 1993;4:50-55.
34. McCarthy JC, Mattingly D, Turner RH, et al: Revision of the deficient femur with a modular femoral component. *Orthop Trans* 1993;17:966.
35. Lawrence JM, Engh CA, Macalino GE: Revision total hip arthroplasty: Long-term results without cement. *Orthop Clin North Am* 1993;24:635-644.
36. Paprosky WG, Jablonsky W, Magnus RE: Cementless femoral revision in the presence of severe proximal bone loss using diaphyseal fixation. *Orthop Trans* 1993;17:965-966.
37. Wagner H: Revisionsprosthese für das Hüftgelenk. *Orthopade* 1989;18:438-453.