 ACTA CHIRURGIAE ORTHOPAEDICAE
ET TRAUMATOLOGIAE ČECHOSL., 73, 2006, p. 145–150

ORIGINAL PAPER
PŮVODNÍ PRÁCE

A Radiographic Review of 135 Total Hip Charnley Arthroplasties followed between 15 and 35 Years

Rentgenologické zhodnocení 135 totálních náhrad kyčelního kloubu podle Charnleyho sledovaných 15 až 35 let

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ABSTRACT

The long-term radiologically interpreted results of low-friction Charnley hip arthroplasties have been previously suggested to be influenced by surgical details, such as orientation of the femoral component, degree of coverage of the plastic acetabulum and other features. We carefully analyzed the radiographs of 135 Charnley arthroplasties that had remained functional, had not been revised and had follow-ups between 15 and 35 years. Several common denominators were identified amongst these radiographs: 93.5% arthroplasties had 100% coverage of the acetabular component; 88% had acetabular inclination between 40–45°; 84.5% had a proximal/medial column of cement between 3 and 5 millimeters at the level of femoral head resection; 81% had a femoral canal/stem ratio more than 50%; and 84% had a column of cement that extended below the tip of the prosthesis. This study supports the importance of technical surgical details that enhance the chances of long-term survival of cemented total hip arthroplasties.

Key words: total hip, long-term follow up, Charnley.

Despite the fact that the field of total hip arthroplasty continuous to evolve and the use of acrylic cement as the means to stabilize the prosthetic components has significantly lost grounds to noncemented porous fixation the Charnley low-friction arthroplasty remains the gold-standard against which other arthroplasties are measured. Long-term results with the Charnley total hip arthroplasty have been reported by a number of investigators (1, 2, 3, 5, 16, 11, 12, 10, 19, 20). No clear reasons have been given to explain why the fate of the Charnley arthroplasty has withstood the test of time in such a superior manner despite major advances in the understanding of the chemical and mechanical behavior of foreign bodies implanted in the body. Upon completing a 35-year follow-up of our experience with the Charnley arthroplasty we undertook the task of studying the radiological condition of 135 arthroplasties with a minimum follow-up of 15 years and a maximum of 35 years in order to determine if common denominators could be identify that would shed light into the subject.

MATERIAL AND METHODS

From a group of 383 patients who had 470 Charnley arthroplasties (87 bilateral) performed by the senior author (A.S.) between July 1970 and July 1975, 39 (8.29%) joints were known to have been revised; their mean age was 62±13 years and their mean weight 67 kg. The mean follow-up until revision was 122±months with a maximum of 270 months. 244 (63.7%) patients were lost to follow-up prior to their reaching 15 years after surgery. It is assumed many of them had expired or that the loss to follow-up was due to other reasons, such as revision surgery performed elsewhere or simply patients' unwillingness or inability to respond to our requests. Four (1%) patients were alive but their x-rays could not be obtained. Analysis of radiographs was conducted in the 135 hips of the 109 (28%) patients who were available for review between 15 and 35 ears after surgery. We had discontinued further gathering of follow-up data when the maximum follow-up of 25 years was reached. Subsequently we decided to increase the follow-up to the 35 years mark. The added data constitutes the material presented in this study.

The Charnley total hip replacements were performed through a lateral approach with trochanteric osteotomy. Non-pressurized finger packing of the cement was followed by insertion of the components. No medullary canal plugging was used in any instance. The original 50-mm acetabular cup was used in all patients. The femoral component consisted of the classical monoblock smooth, shiny 22 mm Charnley implant made of stainless steel (Zimmer). 368 (78%) arthroplasties had curved stems; 36 (7.6%) arthroplasties had straight stems; and 66 (14%) arthroplasties had the Cobra style stems. The Cobra prostheses had matted surfaces.

From the original total group of 383 patients, 287 (74%) had a primary diagnosis of osteoarthritis. In this subgroup, 299 (72.8%) patients had idiopathic osteoarthritis; 68 (23.6%) patients had osteoarthritis sec-

ondary to hip dysplasia, and 10 (3.4%) patients had osteoarthritis secondary to other conditions i.e. Perthes disease, slipped capital femoral epiphysis; 53 (13.8%) patients had rheumatoid arthritis; 10 (2.6%) patients had a painful endoprosthesis; 21 (5.4%) patients had idiopathic avascular necrosis of the femoral head; 9 (2.5%) patients had post-traumatic avascular necrosis of the femoral head, 2 (0.5%) patients suffered from ankylosing spondylitis; and one (0.2%) patient had an spontaneously fused hip secondary to head injury.

From the overall group of 383 patients who had 470 Charnley arthroplasties (87 bilateral) performed by the senior author (A.S.) between July 1970 and July 1975, 39 (8.29%) joints were known to have been revised; their mean age was 62±13 years and their mean weight 67 kg. The mean follow-up until revision was 122±months with a maximum of 270 months. 244 (63.7%) patients were lost to follow-up prior to their reaching 15 years after surgery. It is assumed many of them had expired or that the loss to follow-up was due to other reasons, such as revision surgery performed elsewhere or simply patients' unwillingness or inability to respond to our requests. Four (1%) patients were alive but their x-rays could not be obtained. The progression of various radiological changes was monitored on a yearly basis which at the 25-year mark had indicated the survival to be as shown in tables 1, 2 and 3.

From the total group of 383 patients, 287 (74%) had a primary diagnosis of osteoarthritis. In this subgroup, 299 (72.8%) patients had idiopathic osteoarthritis; 68 (23.6%) patients had osteoarthritis secondary to hip dysplasia, and 10 (3.4%) patients had osteoarthritis secondary to other conditions e.g, Perthes disease, slipped capital femoral epiphysis; 53 (13.8%) patients had rheumatoid arthritis; 10 (2.6%) patients had a painful endoprosthesis; 21 (5.4%) patients had idiopathic avascular necrosis of the femoral head; 9 (2.5%) patients had post-traumatic avascular necrosis of the femoral head, 2 (0.5%) atients suffered from ankylosing spondylitis; and one (0.2%) patient had an spontaneously fused hip secondary to head injury.

Weight bearing began within a few days after surgery, but full, unprotected weight bearing was postponed for six weeks. All patients were contacted on a yearly bases at which time they were either seen personally or were asked to obtain radiographs of their operate hips and to complete a simple questionnaire concerning the presence or absence of pain and the need and type of assisted ambulation.

The 109 patients available for long-term follow-up had 135 arthroplasties performed. Twenty-seven (24.7%) patients had bilateral replacements; 21 (77.7%) of these arthroplasties were performed at different times; and 6 (22.2%) arthroplasties were performed simultaneously. 115 (85%) stems were curved; 6 (4%) stems were straight; and 14 (10%) stems were of the cobra type. Forty-two (38.5%) patients were males and 67 (61.4%) patients were females. The mean weight of the patients who had curved stems was 67 kg; in the patients who had straight stems the mean weight was 65.5 kg;

TABLE 1

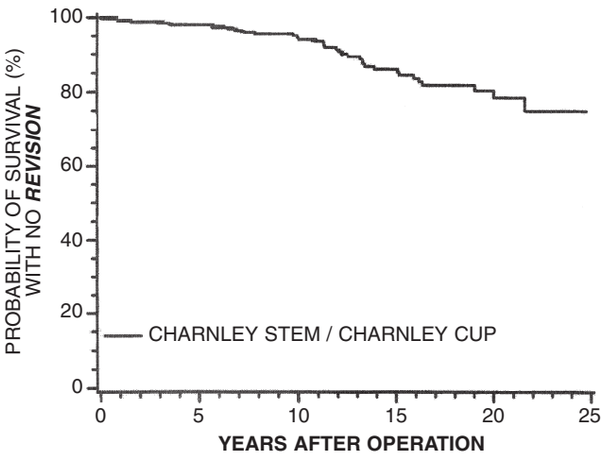


TABLE 2

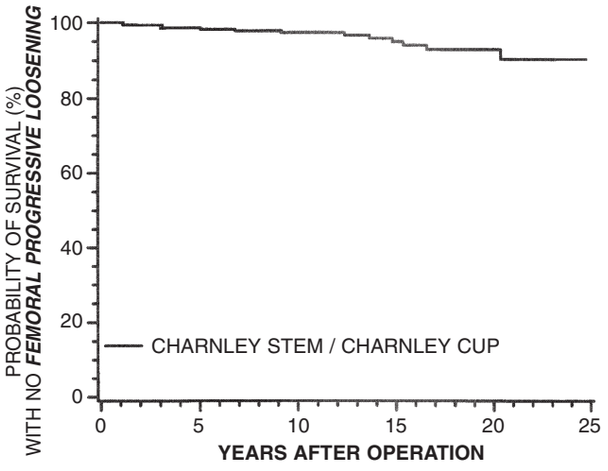
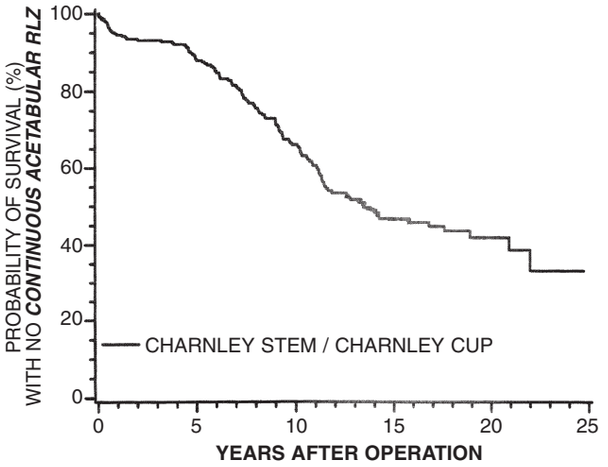


TABLE 3



and in the patients who had cobra stems the mean weight was 68 kg. Among the patients who had unilateral replacement, 49 (44.9%) procedures were performed on the right hip, and 32 (29.3%) procedures were performed on the left hip.

The age of these 109 patients at the time of surgery ranged from 16 to 71 years. Three (2.7%) patients were between 16 and 20 years of age; two (1.8%) patients were between 21 and 30 years of age; 8 (7.3%) patients were between 31 and 40 years of age; 17 (15.5%) patients were between 41 and 50 years of age; 29 (26.6%) patients were between 51 and 60 years of age; 45 (41.2%) patients were between 61 and 70 years of age and 5 (4.5%) patients were 71 years of age (Table 4).

The diagnoses for which the arthroplasties were performed are shown in table 5.

The immediate post-operative radiographs were studied concerning the coverage and inclination of the acetabular component, the attitude of the femoral stem in the medullary canal, the thickness of the cement at the level of the calcar, the distal extension of the cement in reference to the tip-end of the femoral stem, and the ratio between the diameter of the stem and the diameter of the medullary canal seven centimeters below the base of the neck of the prosthesis.

RESULTS

This study does not include clinical data regarding pain or mode of ambulation of the studied patients and constitutes simply a radiographic evaluation. We concluded that the clinical information available was incomplete and to a great extent unreliable, since there were no means to determine in many instances whether patients lost to follow-up had died, their hips had been revised elsewhere or simply were not interested or capable of responding to requests made to them for additional information. In some instances it was chosen to consider certain patients as having expired because of their very advanced age at the time of the last follow-up visit. In addition, the project was strictly a radiological evaluation of films taken of patients who had a minimum follow-up of 15 years.

The mean weight of the 3 patients who were between 16 and 20 years of age at the time of surgery was 56 kg. (range 52–57 kg). In the 21–30 age group was 59 kg. (range 56–69 kg); in the 31–40 age group was 63 kg. (range 61–78 kg.); in the 41–50 age group was 67 kg. (range 57–89 kg.); in the 51–60 age group was 641 kg. (range 55–70); in the 61–70 age group was 62 (range 55–70 kg); an in the >70 age group was 60 kg (range 55–68 kg).

The follow-up ranged from 15 to 35 years as shown in table 6.

The features findings identified radiologically included among others the degree of acetabular coverage, inclination of the acetabular component, ratio of stem/canal diameter (Table 7).

TABLE 4. *Age range 16–71 years at the time of surgery*

Age (years)	Number of patients	Mean weight (kg)	Weight range (kg)
16–20	3 (2.7%)	56	52–57
21–30	2 (1.8%)	59	56–69
31–40	17 (15.5%)	63	61–78
41–50	45 (41%)	67	57–89
51–60	29 (26.6%)	61	54–76
61–70	8 (7.3%)	62	55–70
> 70	5 (4.5%)	60	55–68

TABLE 5. *Diagnoses*

Diagnoses	# patients	Percentage	Mean Weight (kg)
Osteoarthritis	94	86.2%	66
Idiopathic 71 (75.5%)			
Dysplasia 20 (21.1%)			
Others 3 (3.1%)			
Rheumatoid Arthritis	4	3.6%	62
Failed endoprostheses	5	4.5%	62
Ankylosing Spondylitis	1	0.9%	60
Avascular necrosis	4	3.6%	63
Idiopathic 2 (50%)			
Trauma 2 (50%)			
Hip fusion	1	0.9%	52

TABLE 6. *Follow-up range: 16–35 years*

Follow up brackets	Number of patients	Percentage
16–20 yrs.	43	32.7%
21–24 yrs.	38	28.3%
25–29 yrs.	44	32.8%
30–35 yrs.	10	7.6%

TABLE 7. *Technical features*

Description of feature measured	Measure	%
Acetabular coverage	100%	93.5 %
	80–90%	6.5 %
Acetabular inclination	40°–50°	88 %
Femoral component alignment.	Neutral	82.9 %
	Valgus	7.4 %
	Varus	9.6 %
Ratio of stem/ medullary canal	> 50%	81 %
(At 7 cm.)	50%	8 %
	< 50%	9.6%
Cement thickness	0–3 mm	3.7 %
(Proximal Femur)	3–5 mm	84. 5 %
	> 5 mm	11.8 %
Cement extension	Above tip	9 %
	Tip level	7 %
	Below tip	84 %

The following are representative radiographs (Fig. 1, 2, 3).

The abnormal changes identified in the latest radiograph included among others acetabular migration, femoral/bone radiolucent lines and wear (Table 8).

DISCUSSION

Despite the plethora of different total hip prostheses brought into the market during the past three decades, it

FIG. 1. Radiograph of Charnley arthroplasty 33 years after surgery performed in a 40 year old osteoarthritic woman. Notice the distal cortical hypertrophy. The stem is in a neutral attitude and the column of cement is intact.

FIG. 2. Radiograph of Charnley arthroplasty 33 years after surgery performed in a 38 year old active osteoarthritic man, who is 6- feet, 3 inches tall. Notice the resorption of the calcar femoralis and a metal/cement radiolucent line in zone I. The prosthesis filled <50% of the canal at 7 centimeters below the femoral neck resection, and the column of cement extended to the level of the tip of the prosthesis.

FIG. 3. Radiograph of Charnley arthroplasty 33 years after surgery performed in a 43 year old osteoarthritic woman. Notice the metal-cement radiolucent line in zone I.

is not possible at this time to state categorically that any one system or implant is significantly superior to all others. The non-cemented system of hip arthroplasty came into being on the belief that acrylic cement was associated with complications such as loosening and lysis (7, 8) However, for some time after the popularization of the original non-cemented arthroplasty, it became evident that bone lysis was more likely to develop with these implants. Modifications in the geometry of the implants and the distributions of the porous area seem to have significantly improved the results (2, 7, 8).

Reviews of clinical and radiological results with the Charnley implant have suggested that certain details influence the long-term outcome of the surgical replacement, for example, the degree of coverage and inclination of the acetabular component (3, 6, 13); the attitude of the stem in the medullary canal, i.e. varus, valgus, neutral (1, 4, 6, 14, 16, 20), the thickness of the column of cement at the level of the proximal/medial femoral cortex (2, 4, 6, 8, 10, 18) he ratio between the diameter of the femoral implant and that of the femoral component (4, 5, 17) the patients age at the time of surgery and the disease for which the surgery is performed (1, 3, 5, 12, 14).

Based on the above information we elected to review our Charnley arthroplasties that had survived between fifteen and thirty-three years to determine if the radiological and clinical features that have been previously identified were present in the long-surviving hips. We did not include in this study those patients who for a variety of reasons were not followed more than 15 years, since we were only interested in evaluating the radiological performance of implants followed longer than

TABLE 8. *Abnormal changes*

Description of changes measured	Measure	% patients
Acetabular migration	None	96.2 %
	<5 mm	2.9 %
	> 5mm	0.7%
Acetabular bone/cement radiolucent lines	None	94.1%
	>1 mm	5.9 %
Femoral bone/cement radiolucent lines	None	95.5%
	>1 mm	4.4%
Femoral metal/cement radiolucent lines	None	97.7%
	Present	2.3%
Cement fracture	None	96.2%
	Present	3.7 %
Polyethylene wear	None	30 (14.8%)
	1–3 mm	89 (66%)
	3–5 mm	13 (9.6%)
	>5 mm	3 (2.2 %)
Broken wires	None	85.5 %
	Broken	14.5%
Acetabular Lysis	None	95.6%
	< 5 mm	4.4%
Femoral Lysis. (Neck resorption)	None	95.6%
	<5 mm	4.4%

fifteen years. It is well-known that virtually all different types of total hip implants seem to render good radiological results for a few years, only to demonstrate failure after fifteen years of clinical performance.

This review indicated that the vast majority of patients had met the previously identified observations. 1) 93.3% hips had 100 percent coverage of the acetabular component. 2) 88% hips had the acetabular component inclined between 40 and 45 degrees and 8.8% hips between 45 and 50 degrees. 3) 82.9% hips had the femoral component in a neutral attitude and 9.6% in a valgus attitude, while only 7.5% had the implants in varus. 4) 84.4% hips had a column of cement at the level of the transected femoral neck a thickness between 3 and 5 millimeters. 5) 81.4% hips had femoral stems that occupied more than 50% of the diameter of the medullary canal. 6) 84% hips had a column of cement that extended below the tip of the prosthesis.

Review of the radiographs of this group of patients with long-term follow-up demonstrated a low incidence of findings commonly known as being of an undesirable nature, some of which are generally considered to be signs of early failure. 1) Absence of measurable acetabular migration was documented in 96.2% hips. 2) 94.7% hips did not have continuous acetabular bone/cement radiolucent lines. 3) 95.5% hips did not show continuous cement/bone radiolucent lines. 4) 97.7% hips did not have femoral metal/cement radiolucent lines. 5) 96.2% hips did not have fractures of the femoral cement column. 6) Wear of the acetabular polyethelene component was found in most hips; only 14.8% hips did not have measurable wear. 7) Minimal femoral lysis was present in 4.4% radiographs; and acetabular lysis was documented in 2.5% patients. It is interesting to note that neither the age nor the weight of the patients at the time of surgery seem to correlate with acetabular wear, bone-cement or metal cement radiolucent lines The small number of patients in the series and particularly in each category of „abnormal changes“ precluded the statistical analysis that is possible with larger series.

The data we gathered suggest that the patients' weight may not be important in view of the fact since it was similar in analyzed parameters, such as disease categories, i.e. osteoarthritis, avascular necrosis, rheumatoid arthritis (Tables 4 and 5).

Clinical data was not reported in the current review despite the fact that attempts to gather pertinent information was made on a yearly basis. The patients' clinical performance was not discussed because we considered the information obtained from questionnaires to be frequently unreliable, such as the use of external support or ability to walk long distances. We had long-realized that elderly people, for reasons frequently unrelated to the operated hips, use a cane or walker, not because of pain in the hip, but because associated degenerative conditions require their use. Often, elderly patients afflicted with multiple physical or mental problems do not appropriately respond to questions asked in written questionnaires, and frequently report the presence of pain. Subsequent telephone conversation with them makes it obvious that quite often the alleged symptoms are due to spine and other joints' pathology rather than to hip disease. It is likely that patients whose radiographs do not show certain abnormal changes are likely to have asymptomatic hip joints.

It is not uncommon to see patients whose radiographs show significant abnormal changes who, nonetheless have minimal discomfort or are totally asymptomatic. Therefore, one may conclude that revision surgery is not an accurate end-point criterion in determining success or failure of total hip arthroplasties. There are also times when painful arthroplasties are never revised for a variety of reasons, such as the presence of medical conditions that preclude surgery or patients' unwillingness of undergo additional surgery.

The data obtained from this study does not provide information regarding the impact that the described technical features may have had in the degree of wear of the polyethylene acetabular component.

This review does not intend to imply that long-term success of Charnley arthroplasties can be assured if the technical details identified in the text are carefully implemented. However, the information obtained strongly suggests that successful radiological long-term results from Charnley arthroplasty- and perhaps also from other types of cemented arthroplasties- may be significantly dependent on adherence to the details identified in this study. The identified common denominators strongly suggest that the following technical details are important in influencing a satisfactory long-term follow-up: complete coverage of the acetabular component, an angle of inclination of the acetabulum between 40° and 50°, a neutral attitude of the stem in the medullary canal, a ratio of stem/canal diameter greater than 50%, a column of cement proximally between 3–5 mm., and a column of cement that extends below the tip-end of the metallic stem (Tables 7 and 8).

ZÁVĚR

Již dříve bylo popsáno, že u totální náhrady s použitím komponenty s nízkým otěrem podle Charnleyho jsou dlouhodobé, radiologicky hodnocené výsledky ovlivněny operačními faktory, jako jsou orientace femorální komponenty, stupeň pokrytí plastické jamky a další. Pečlivě jsme analyzovali rtg-snímky 135 totálních náhrad podle Charnleyho, které byly funkční, nebyly revidovány a doba sledování se pohybovala od 15 do 35 let. Na základě snímků byly zjištěny následující společné znaky: 93,5 % náhrad mělo stoprocentní zakrytí jamky; 88 % mělo sklon jamky 40°–45°; 84,5 % mělo proximálně mediálně sloupec cementu šíře mezi 3–5 mm v úrovni resekce hlavice femuru; u 81 % byl poměr femorálního kanálu ku dříku protézy více než 50 % a u 84 % zasahoval sloupec cementu pod špičku dříku protézy.

Výsledky této studie ukazují na význam technických detailů operačního výkonu, které zvyšují vyhlídky na dlouhodobé přežití cementované totální náhrady kyčelního kloubu.

References

1. BERRY, D., HAMSEN, S., CABANELA, M., MORREY, B.T.: Twenty-five year survivorship of two thousand consecutive Charnley total hip replacements: Factors affecting survivorship of acetabulum and femoral components. J. Bone Jt Surg., 84-A: 171–177, 2002.
2. CAPELLO, W., HELLMAN, E., FEINBERG J.: Proximally porous-coated total hip arthroplasty. Hip Surgery-Materials and Developments. Editors: L. Sedel and M. Cabanela. Martin Dunitz Publish 1998, 235–242.
3. COLLIS, D., K.: Cemented total hip replacement in patients who are less than fifty years old. J. Bone Jt Surg., 66-A: 358–359, 1984.
4. EBRAMZADEH, E., SARMIENTO, A., McKELLOP, H., LLINAS, A., GOGAN, W.: The Cement Mantle in Total Hip Arthroplasty: Analysis of Long Term Radiographic Results. J. Bone Jt Surg., 76-A: 77–87, 1994.
5. EBRAMZADEH, E., NORMAN, P., SANGIORGIO, S., LLINAS, A., GRUEN, T., McKELLOP, H., SARMIENTO, A.: Long-term radiographic changes in cemented total hip arthroplasty with six designs of femoral components. J. Biomaterials, 2: 335–3363, 2003.
6. EFTEKHAR, S.S.: Long-term results of cemented total hip arthroplasty. Clin. Orthop., 225: 217, 1987.
7. ENGH, C.: The Anatomic Medullary Locking Prosthesis. Total Hip Arthroplasty Outcomes. Churchill Livingston 1998, 117–139.
8. GALANTE, J., ROSTOKER, W., DOYLE, J. M.: Failed femoral stems in total hip prostheses. J. Bone Jt Surg., 57-A: 230, 1975.
9. KLAPACH, A. S., CALLAHAN, J., GOETZ, D. O., OLEJWICZAK, J. P., JOHNSTON, R. C.: Charnley total hip arthroplasty with use of improved cemented technique. A minimum twenty-year follow-up study. J. Bone Jt Surg., 83-A: 1333–1338, 2001.
10. SALVATI, E. A., WILSON, P. Jr., JOLLEY, M. N.: A ten-year follow-up study of our first one hundred consecutive Charnley total hip replacements. J. Bone Jt Surg., 63-A: 753–767, 1991.
11. SARMIENTO, A., NATARAJAN, V., GRUEN, T.A., McMAHON: Radiographic Performance of Two Different Total Hip Cemented Arthroplasties. Orthop. Clin. N. Amer., 1–11, 1988.
12. SARMIENTO, A.: Reflections on a 25 year experience with total hip arthroplasty. In: Finerman, G., Grigoris, P., Dorey, F., McKellop, H., eds: Total Hip Arthroplasty Outcomes. New York, Churchill Livingston 1997.
13. SARMIENTO, A., EBRAMZADEH, E.,GOGAN, W.J. McKELLOP, H.A.: Acetabular Cup Containment and Orientation in Cemented Total Hip Arthroplasties. J. Bone Jt Surg., 72-B: 996–1002, 1990.
14. SARMIENTO, A., EBRAMZADEH, E., GOGAN, W.J. McKELLOP, H.: Total Hip Arthroplasty with Cement: A Long-Term Radiographic Analysis in Patients Who Are Older Than Fifty Years. J. Bone Jt Surg., 72-A: 1470–1476, 1990.
15. SARMIENTO, A., EBRAMZADEH, E.: The Stainless Steel and Titanium Alloy Femoral Prostheses. In: Finerman, G. et al.: Total Hip Arthroplasty Outcomes. Churchill Livingston 1997.
16. TAPADIYA, D., WALKER, R. H., SCHURMAN, D. J.: Prediction of outcome of total hip arthroplasty based on initial postoperative radiographic analysis. Clin. Orthop., 186:5–15, 1984.
17. TARR, R., LEWIS, J., JAYCOX, D., SARMIENTO, A., SCHMIDT, J., LATTA, L.: Effect of materials, stem geometry, collar-calcar contact on stress distribution on the proximal femur with total hip. Trans. Orthop. Research Soc., 4:24, 1979.
18. TARR, R. R., CLARKE, I. C., GRUEN, T., SARMIENTO, A.: Predictions of cement-bone failure criteria. Three-dimensional finite element models versus clinical reality of total hip replacements. Finite Elements in Biomechanics, Simon, B. R. (ed). London, John Wiley and Sons, Ltd. 1981.
19. WELCH, R. B., McGANN, W. A., PICETTI, G. D., III.: Charnley low-friction arthroplasty: a 17-17 year follow-up study. Orthop. Clin. N. Amer., 19: 551–556, 1988.
20. WROBLEWSKI, B.: Charnley low-friction arthroplasty of the hip. Long-term results. Clin. Orthop., 292:191–201, 1993.

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Práce byla přijata 18. 4. 2006.