Primary Noncemented Total Hip Arthroplasty in Patients With Ankylosing Spondylitis

Clinical and Radiographic Results at an Average Follow-up Period of 6 Years

Mark R. Brinker, MD,*†‡ Aaron G. Rosenberg, MD,§ Laura Kull, MS,§ and Dennis D. Cox, PhD||

Abstract: Twenty consecutive primary noncemented total hip arthroplasties performed on 12 men with ankylosing spondylitis were available to be studied clinically and radiographically at an average follow-up period of 75 months (range, 27–121 months). The average patient age at the time of surgery was 35 years (range, 23–53 years). Harris hip scores averaged 48.4 before surgery and 89.1 at the most recent follow-up examination. Significant improvements in pain, function, and range of motion were observed following total hip arthroplasty. No hip has required a surgical revision or reoperation. Heterotopic ossification was observed in 6 of 14 hips (43%) in the ankylosing spondylitis patients who had not had any perioperative prophylaxis for heterotopic bone formation. By contrast, 43 of 49 hips (88%) demonstrated heterotopic bone formation in a well-defined control group of 45 men with other diagnoses undergoing the same procedure by the same group of surgeons at the same institution. During the same period using the same implants. A thorough review of the literature and data from the institution does not support the notion that ankylosing spondylitis patients are necessarily predisposed to form heterotopic ossification. The use of routine perioperative prophylaxis for heterotopic ossification may not be warranted in all patients with ankylosing spondylitis undergoing routine primary noncemented total hip arthroplasty. **Key words:** hip, arthroplasty, noncemented, ankylosing spondylitis, heterotopic ossification.

Ankylosing spondylitis is a seronegative spondyloarthropathy characterized by inflammation of the sacroiliac joints, axial spine, and peripheral joints. Extraskeletal manifestations of ankylosing spondylitis include iritis, aortitis, pulmonary fibrosis, colitis, arachnoiditis, and amyloidosis [1]. Peripheral joint involvement has been reported in 20 to 73% of cases, with the hip being the most commonly involved large joint [2,3]. The current well-accepted treatment for advanced symptomatic disease of the hip in ankylosing spondylitis is total hip arthroplasty (THA), and a number of authors have reported their results using cemented techniques [4–12]. Few reports, however, have been published concerning the use of components implanted without cement in these patients [13], and the indications for this technique in ankylosing spondylitis remain unclear. The choice of implant fixation is particularly important for long-

*From the §Department of Orthopaedic Surgery, Rush–Presbyterian–St. Luke's Medical Center, Chicago, Illinois, *Department of Orthopaedic Surgery, Tulane University School of Medicine, New Orleans, Louisiana, †Department of Orthopaedic Surgery, University of Texas Health Science Center, Houston, ‡Fondren Orthopedic Group LLP, Texas Orthopedic Hospital, Houston, and ||Department of Statistics, Rice University, Houston, Texas.*

Reprint requests: Mark R. Brinker, MD, Fondren Orthopedic Group LLP, 7401 S. Main, Houston, TX 77030.

term hip function and durability in this relatively young and active group of patients where decreased motion of the spine may result in increased forces at the hip joint [6].

Another area that remains unclear is whether patients with ankylosing spondylitis undergoing THA are particularly predisposed to forming heterotopic ossification and whether perioperative prophylaxis is warranted. A number of authors have studied the formation of heterotopic bone in their series of hip arthroplasties in patients with ankylosing spondylitis [5–18], but the reported incidence has varied widely from 4 to 100% [9,14]. Some authors have suggested that patients with ankylosing spondylitis undergoing hip arthroplasty are at increased risk for forming heterotopic ossification [8,10,11,15,17–23]. Other authors have disputed this notion [7,14], and the subject remains controversial.

The purpose of this investigation was to document the clinical and radiographic results of a consecutive series of patients with ankylosing spondylitis who had undergone primary THA using noncemented components. Our first aim was to document clinical results following surgery in terms of pain relief and improvement in function and hip range of motion. Our second aim was to document the incidence of heterotopic bone formation in a group of patients with ankylosing spondylitis undergoing primary noncemented THA and compare this with that for a well-defined control group of our patients with other diagnoses who had the same procedure. To the best of our knowledge, such a study has not previously been reported in the literature.

Materials and Methods

Between November 1983 and August 1990, 24 consecutive primary noncemented THAs were performed on 14 patients with ankylosing spondylitis. At the most recent follow-up examination, 20 hips in 12 patients were available for evaluation and 4 hips in 2 patients had been lost to follow-up evaluation. The average follow-up period for the 20 hips available for evaluation was 75 months (range, 27–121 months). All patients included in the current series met the diagnostic criteria of ankylosing spondylitis [24] and had been followed by a rheumatologist on a routine basis. In no patient was there evidence of any other seronegative spondyloarthropathy. The primary indication for THA was painful limitation to range of motion that was unresponsive to nonsurgical treatment and limiting to ambulation and activities of daily living. No patient had preoperative clinical or radiographic evidence of complete ankylosis of the hip.

The average age of all patients at the time of reconstructive hip surgery was 35 years (range, 23–53 years). The average patient age at the time of diagnosis of ankylosing spondylitis in our 12 patients was 23.1 years. No patient had had any prior surgery to the involved hip. Four patients underwent unilateral reconstructions and eight underwent bilateral surgeries. Of the eight bilateral cases, four were implanted in one operative setting. Surgery was performed on 10 right and 10 left hips. All arthroplasties were performed in white men. Regarding socioeconomic factors, all patients had some form of private medical insurance and no patient had a family income below the poverty level [25,26]. Regarding comorbid medical conditions, one patient (patient 5, Table 1) had two major medical conditions [25] (hypertension and a myocardial infarction in the past). Table 2 shows the extraskeletal manifestations of ankylosing spondylitis in our patients; 7 of 12 patients had extraskeletal manifestations.

Total hip reconstruction was performed by five full-time faculty surgeons specializing in adult reconstructive joint surgery at Rush–Presbyterian–St. Luke's Medical Center (Chicago, IL). All operative procedures were performed in an operating room equipped with a vertical laminar-flow clean-air system and body exhaust suits. A posterior surgical approach was performed in 3 hips and a Hardinge approach was performed in 17 hips. A trochanteric osteotomy was not performed during any of the 20 procedures.

Prior to 1990, no routine protocol for perioperative heterotopic ossification prophylaxis existed at our institution. Of the 20 hips in this investigation, 6 received perioperative prophylaxis for heterotopic bone formation; 2 hips received postoperative radiation therapy and 4 hips were in patients who received a course of indomethacin (50 mg orally, three times per day, for 28 days) in the immediate postoperative period (Table 1). Fourteen of 20 hips in ankylosing spondylitis patients received no prophylaxis for heterotopic bone formation (Table 1). The decision for or against perioperative prophylaxis was made by the faculty surgeon in charge of each case, as no routine protocol or guidelines existed at our institution during the time frame of this retrospective study.

A summary of the prostheses used in our patients is shown in Table 1. Implantation of all prostheses was performed in accordance with the manufacturers' recommended noncemented technique.

Table 1. Data for All Patients With Ankylosing Spondylitis

Patient No.	Side	Age at Diagnosis of Ankylosing Spondylitis (years)	Age at THA (years)	Perioperative Heterotopic Ossification Prophylaxis	Surgical Approach	Prosthesis Type (Femoral/Acetabular)	Follow-up Period (months)	Harris Hip Score*	Heterotopic Ossification (Brooker Class [27])*
1	L	20	23	None	Hardinge	Mark II/T-Tap	121	69	None
	R		25	None	Posterior	HG/HG I	93	69	None
2†	R	26	26	None	Hardinge	HG/HG I	80	92	II
	L		26	None	Hardinge	HG/HG I	80	88	I
3†	L	13	35	None	Hardinge	HG/HG I	71	83	None
	R		35	None	Hardinge	HG/HG I	71	83	None
4	L	40	42	Radiation‡	Hardinge	HG/HG I	98	95	None
	R		48	Radiation§	Hardinge	HG/HG II	27	92	None
5†	R	30	53	None	Hardinge	HG/HG I	85	88	None
	L		53	None	Hardinge	HG/HG I	85	93	None
6†	R	22	28	None	Hardinge	HG/HG I	62	85	II
	L		28	None	Hardinge	HG/HG I	62	85	I
7	R	22	52	None	Hardinge	HG/HG I	64	93	None
	L		53	None	Hardinge	HG/HG I	48	93	I
8	L	22	42	Indomethacin‖	Posterior	HG/HG I	96	95	None
9	R	21	28	None	Posterior	Bias/HG II	69	99	None
10	R	30	34	None	Hardinge	Anatomic/HG II	51	91	II
11	L	12	23	Indomethacin‖	Hardinge	HG/HG I	87	98	None
	R		23	Indomethacin‖	Hardinge	HG/HG I	85	98	None
12	L	19	31	Indomethacin‖	Hardinge	HG/HG I	66	93	II

L, left; R, right; Mark II, Mark II femoral component (Zimmer, Warsaw, IN); HG, Harris–Galante porous hip femoral component (Zimmer); Bias, Bias modular femoral stem (Zimmer); Anatomic, Anatomic hip prosthesis (Zimmer); HG I, Harris–Gallante I acetabular component (Zimmer); HG II, Harris–Galante II acetabular component (Zimmer); T-Tap, T-Tap acetabular component (Biomet, Warsaw, IN). *At most recent follow-up examination. †Indicates bilateral procedures performed in one operative setting. ‡Five postoperative doses of 200 rad (total, 1,000 rad). §One postoperative dose of 500 rad. ‖50 mg orally, three times per day for 28 days.

Table 2. Overview of Extraskeletal Manifestations of Ankylosing Spondylitis

Extraskeletal Manifestations of Ankylosing Spondylitis	No. of Patients
Iritis	1
Aortitis	0
Pulmonary fibrosis	5
Colitis	4
Arachnoiditis	0
Amyloidosis	0
Sarcoidosis	1

Clinical and Radiographic Evaluation

Patients were evaluated clinically using both subjective and objective information based on the Harris hip score system [28]. Postoperative evaluation of patients was performed at 6 weeks, 3 months, 6 months, 12 months, and yearly thereafter. Clinical evaluation for the purpose of calculating Harris hip scores was performed by clinical research nurses who were not part of the surgical team.

Radiographic evaluation was performed in a blinded manner by a single trained technician who had no knowledge of the patient's clinical history. Detailed analysis of standardized anteroposterior radiographic views of the pelvis and femur and a lateral view of the femur were performed at each clinical interval. Quantitative analysis was performed using a Sigma Scan Digitizing System (Jandel Scientific, Corte Madera, CA) [29,30].

Subsidence of the femoral component was determined through serial anteroposterior radiographic measurements of the distance between the tip of the greater trochanter and a standardized site on the proximal portion of the implant [29,30]. The bone–prosthesis interface was evaluated for radiolucencies in zones on both anteroposterior [31] and lateral [32] radiographs.

A femoral component was considered "definitely unstable" if there was subsidence greater than 2 mm over time [29,30]. Progressive subsidence was defined as 2 mm or more observed on two successive radiographs [29,30]. A femoral component was considered "possibly unstable" in the presence of complete radiolucencies over the entire porous-coated surface [29,30]. The presence of endosteal cortical erosions of the femur was documented.

Acetabular inclination was measured using the interteardrop line as a reference point [29,30]. Acetabular inclination was considered acceptable between 35° and 55° [29,33]. To assess possible acetabular migration, acetabular position was defined using measurements from standardized anatomic landmarks to the center of rotation of the prosthetic femoral head [29,30]. Migration of the acetabular component measuring greater than 2 mm in the vertical and/or horizontal plane was the radiographic criterion for "definite instability" [29,30]. We used the method of Martell et al. [30] to assess the extent and location of radiolucent lines at the acetabular bone–prosthesis interface. An acetabular component was considered "possibly unstable" if radiolucencies were recorded in at least four of five zones and the lucency measured at least 2 mm in one of these zones [30].

Heterotopic bone was graded as described by Brooker et al. [27], and classes III and IV were considered "clinically important" as per Kilgus et al. [7]. Heterotopic bone formation in the 14 hips of patients with ankylosing spondylitis who had not had any perioperative prophylaxis for heterotopic ossification was compared with that of a control group of 49 consecutive primary noncemented THAs performed by the same five senior surgeons during the same period (and under the same conditions) in 45 men between the ages of 23 and 53. The breakdown of diagnoses in the 49 control group hips was 16 with osteoarthritis (33%), 29 with osteonecrosis (59%), 2 with rheumatoid arthritis (4%), and 2 with post-traumatic arthritis (4%). Of the 49 procedures performed on the control group, a posterior surgical approach was used in 3 hips and a Hardinge approach was used in 46 hips. Fisher–Irwin analysis revealed no significant difference between the ankylosing spondylitis group and the control group with respect to the proportion of patients in each group who had each surgical approach ($P = .17$). No patient in the control group had had any prior surgery to the involved hip. A trochanteric osteotomy was not performed during any of the 49 procedures in the control hips. No patient in the control group received any form of perioperative heterotopic ossification prophylaxis. The minimum radiographic follow-up period in our 49 control hips was 24 months.

Data were tabulated and subjected to statistical analysis. Student's t-test was used to determine the significance of differences between means. The chi-square statistic was used to determine the significance between proportions except in cases where the proportions and sample sizes were too small; in those cases, we used the Fisher–Irwin exact test. A P value less than .05 was considered significant.

Results

Clinical Findings

The distribution of preoperative and follow-up Harris hip scores for all 20 cases is shown in Table 3.

Table 3. Distribution of Harris Hip Scores, Intensity of Pain, and Functional Outcomes for All Cases in Patients With Ankylosing Spondylitis (n = 20 Hips)

Harris Hip Scores	Preoperative (%)	Most Recent Follow-up Examination (%)
90–100	0	12 (60)
80–89	0	6 (30)
70–79	1 (5)	0
< 70	19 (95)	2 (10)
Revised	—	0
Intensity of pain		
None	0	12 (60)
Slight	0	6 (30)
Mild	3 (15)	2 (10)
Moderate	12 (60)	0
Marked	5 (25)	0
Totally disabling	0	0
Limp		
None	0	10 (50)
Slight	0	8 (40)
Moderate	12 (60)	2 (10)
Severe/non-ambulatory	8 (40)	0
Support		
None	12 (60)	18 (90)
1 cane for long walks	3 (15)	2 (10)
1 cane full time	1 (5)	0
1 crutch	2 (10)	0
2 canes	2 (10)	0
Nonambulatory	0	0
Distance walked		
Unlimited	0	11 (55)
6 blocks	5 (25)	5 (25)
2–3 blocks	11 (55)	4 (20)
Indoors only	3 (15)	0
Bed and chair only	1 (5)	0

Average follow-up period was 75 months.

Scores of 80 or more were seen in 18 of 20 cases (90%) at the most recent follow-up examination. Preoperative Harris hip scores averaged 48.4 points (range, 27–71 points); Harris hip scores at the most recent follow-up examination averaged 89.1 points (range, 69–99 points). Thus far, no patient has required a surgical revision or reoperation on his hip.

Before surgery, the average pain score was 19 points (range, 10–30 points) of a possible 44 points, with patients reporting moderate or marked pain in 17 of 20 (85%) affected hips. At the most recent follow-up examination, pain scores averaged 41.4 points (range, 30–44 points), with 18 cases (90%) having slight or no pain in the affected hip. Overall, 100% of patients reported some relief of painful symptoms (improvement in pain score from preoperative to most recent follow-up examination) following total hip reconstruction. The distribution of intensity of pain and function (limp, support, and distance walked) reported by patients before surgery and at the most recent follow-up examination is shown in Table 3.

Physical examination prior to surgery revealed a flexion contracture of the hip in 16 of 20 cases (80%). The flexion contracture averaged 20° (range, 10°–45°) in these 16 hips. A significant decrease in the average flexion contracture was seen at the most recent follow-up examination, when the flexion contracture averaged 10° ($P = .002$). A significant improvement in the arc of passive flexion was seen following THA. The hip flexion arc averaged only 58° before surgery as compared with 82° at the most recent follow-up examination ($P = .0008$). A similar significant improvement in hip abduction, adduction, internal rotation, and external rotation was seen comparing preoperative arcs of motion with the most recent follow-up arcs of motion ($P \leq .002$) (Table 4).

Complications

Systemic complications of the 20 procedures included a deep venous thrombosis in one case. It should be noted that during the study period, no routine screening for deep venous thrombosis was being performed; therefore, other cases of thrombosis may have become evident had routine screening been used in these cases. No patient in our study group had a clinically detectable pulmonary embolism in the postoperative period. No cases of postoperative urinary tract infection or pneumonia were seen.

Local complications associated with the procedure included three postoperative peroneal nerve palsies. In one patient, incomplete peroneal nerve function returned over the course of several months. The other two patients with peroneal nerve palsies had complete return of function in the weeks following the procedure. One patient sustained an intraoperative nondisplaced fracture at the level of the calcar; this fracture healed uneventfully. There were no deep wound infections. One patient had a stitch abscess in the early postoperative period which was treated successfully with oral antibiotics. No patient had a postoperative dislocation. No case had required surgical revision or any other subsequent procedure to the involved hip. No case had gone on to complete ankylosis.

Radiographic Findings

At the follow-up examination, one femoral component (5%) was considered definitely unstable because it demonstrated progressive subsidence of 9 mm over a 3-year period. One femoral component (5%) was considered possibly unstable because of complete radiolucencies seen on the anteroposterior radiograph. Endosteal cortical erosions were not observed in any case.

Table 4. Average Arcs of Passive Motion in Hips of Patients With Ankylosing Spondylitis (n = 20 Hips)

	Preoperative	Most Recent Follow-up Examination	*P* Value
Flexion*	58°	82°	.0008
Abduction*	14°	35°	.00000002
Adduction*	10°	18°	.002
External rotation*	13°	34°	.00001
Internal rotation*	6°	18°	.0004

Average follow-up period was 75 months. *Denotes significant differences between the preoperative and most recent follow-up arc of motion.

Radiographic evaluation of acetabular components at the most recent follow-up examination revealed an average inclination angle of 46° (range, 26°–64°). An acceptable inclination angle (35°–55°) was seen in 15 of 20 cases (75%). No acetabular component showed migration greater than 2 mm. Complete radiolucencies at the acetabular bone–prosthesis interface were observed in three hips, with one additional component considered possibly unstable. These four cases with radiographic evidence of periprosthetic acetabular radiolucency and possible component instability involved Harris–Galante I acetabular components (Zimmer, Warsaw, IN).

At the most recent follow-up examination, heterotopic ossification was present in 6 of 14 hips (43%) in patients with ankylosing spondylitis who had not had any perioperative prophylaxis for heterotopic bone formation (Tables 1, 5). All six hips with radiographic evidence of heterotopic ossification were Brooker classes I and II. No patient with ankylosing spondylitis demonstrated class III or IV heterotopic ossification. Heterotopic ossification developed in 6 of 12 procedures (50%) performed through a Hardinge approach as compared with zero of 2 procedures performed through a posterior approach in patients with ankylosing spondylitis who had not had perioperative radiation or indomethacin.

At the most recent follow-up examination, heterotopic ossification was observed in 43 of 49 hips (88%) in a control group of men undergoing primary noncemented THA (Table 5). The prevalence of heterotopic ossification in our control group was more than twice that of our ankylosing spondylitis patients; this difference was significant with $P = .0004$ (with Yates' correction, $P = .0014$). Clinically important heterotopic ossification (classes III and IV) was seen in 6 of the 49 control hips (12%) as compared with none of the patients with ankylosing spondylitis ($P = .17$; with Yates' correction, $P = .39$). Heterotopic ossification developed in 42 of 46 control hips (17 class I, 19 class II, 4 class III, and 2 class IV) in which a Hardinge approach was used and in 1 of 3 hips (1 class II) in which a posterior approach was used.

Discussion

Results of this investigation suggest that THA using noncemented techniques provides an acceptable outcome at follow-up periods of 2 to 10 years

Table 5. Comparison of Heterotopic Bone Formation in Men Undergoing Primary Noncemented THA

Heterotopic Ossification at Most Recent Follow-up Examination (Brooker Class [27])	Ankylosing Spondylitis (n = 14 Hips) (%)	Control Group (n = 49 Hips) (%)
None	8 (57)	6 (12)
I	3 (21)	17 (35)
II	3 (21)	20 (41)
III	0	4 (8)
IV	0	2 (4)

$P = .0004$ (with Yates' correction, $P = .0014$) when comparing the proportions of patients with heterotopic bone formation (Brooker classes I–IV) in patients with ankylosing spondylitis and those in the control group. Minimum radiographic follow-up period of 24 months; no patient had prior hip surgery or a trochanteric osteotomy to the involved hip. Age range of all ankylosing spondylitis and control group patients at surgery was 23 to 53 years. Data include only those patients who did not receive perioperative prophylaxis for heterotopic bone formation.

in patients with ankylosing spondylitis. The average Harris hip score improved from 48.4 points before surgery to 89.1 points at an average follow-up period of 6 years, and no hip has required a revision surgery. At the most recent examination, 90% of hips (18 of 20) had a good or excellent clinical result. This compares favorably with the series of ankylosing spondylitis cases of Williams et al., who reported good or excellent clinical results in 73% of 86 cemented arthroplasties [12]; Calin and Elswood, who reported good or very good clinical results in 86% of 138 primary and 12 revision hip arthroplasties [34]; and Bisla et al., who reported good clinical results in 91% of 34 cemented arthroplasties [6].

Our patients all reported improvement in pain following their THA, with 18 of 20 hips (90%) reporting slight or no pain to the involved hip at the most recent follow-up examination. Our results regarding pain relief with noncemented components appear to be equivalent to those of other series of cemented hip arthroplasty in patients with ankylosing spondylitis. Bisla et al. reported mild or no pain in 94% of 34 cemented arthroplasties [6], and Halley and Charnley [35] and Welch and Charnley [36] reported no pain in each of their 17 and 33 respective cases following low-friction arthroplasty. Likewise, Walker and Sledge reported no pain in 97% of 29 cases following cemented THA [11].

Three of our 20 cases had a transient postoperative peroneal nerve palsy. Two of these palsies resolved fully after several months and one case had a partial return. This 15% prevalence seen in our ankylosing spondylitis cases is higher than the 1.4% prevalence (9 of 653 cases) in our consecutive series of primarily noncemented THAs (for all diagnoses) performed during the same period by the same five faculty surgeons. The reason for the increased prevalence of peroneal nerve palsy in these patients remains uncertain. It is possible that significant capsular adhesions secondary to the disease process necessitated increased manipulation and dissection and may predispose to the nerve palsies we observed. Alternatively, the apparent increased prevalence of nerve palsy we observed in our patients with ankylosing spondylitis may be a spurious finding unrelated to the disease entity under study.

All 12 of our patients showed improvement in ambulation following THA. At the follow-up examination, fewer of our patients required a supportive device for ambulation. Our results are comparable to those of Bisla et al., who reported improvement in function in 22 of 23 patients receiving cemented hip arthroplasties [6]. Similarly, Shanahan et al. reported improvement in function in 15 of 16 hip arthroplasties in patients with ankylosing spondylitis [9]. Other authors have likewise reported a significant improvement in function and ambulation following THA in patients with ankylosing spondylitis [5,11,36].

Highly significant improvements in arc of hip flexion, abduction, adduction, internal rotation, and external rotation were seen in our patients at the most recent follow-up examination as compared with preoperative values. A number of authors have reported a similar improvement in arc of hip motion in their patients with ankylosing spondylitis undergoing THA [4,5,7,9,11,36].

Radiographic evaluation revealed evidence of femoral component instability in 2 of 20 cases (10%). One of these cases was considered definitely unstable because it demonstrated progressive subsidence. This 5% rate of progressive subsidence compares well with the 5% incidence reported by Martell et al. [30] for 121 THAs performed using the Harris–Galante femoral component, and the 4% incidence reported by Brinker et al. [29] using predominantly the Harris–Galante femoral component in 81 hips in patients with osteonecrosis of the femoral head. Furthermore, our overall rate of femoral component loosening of 10% compares favorably with the 9% rate reported by Martell et al. [30] using the same femoral prosthesis.

The overall prevalence of radiographic evidence of acetabular loosening was 20% (4 of 20 cases). Although this rate is higher than the 5% rate reported by Kull et al. [37] in 163 hips using the Harris–Galante acetabular component, none of the components in our ankylosing spondylitis patients have required a surgical revision. The reason for the increased incidence of radiographic evidence of acetabular loosening we observed in our patients with ankylosing spondylitis remains obscure, and no definite conclusions regarding this radiographic phenomenon can be drawn from our population. Additionally, it should be noted that the clinical significance of radiolucencies at the bone–prosthesis interface in press-fit acetabular components remains controversial and acetabular radiolucencies may be manifestations of fibrous ingrowth in well-fixed components. Martell et al. reported radiolucent lines in 67 of 120 (56%) press-fit Harris–Galante components [30]; despite this high prevalence of acetabular radiolucencies, good or excellent clinical results were seen in 88% of 121 hips at an average follow-up period of 67 months.

The reported rates of heterotopic bone formation following THA for ankylosing spondylitis have varied widely [5–12,14–18,38]. A thorough review of

the literature reveals that differences in the rates of heterotopic ossification reported may be due to a number of factors, including the use of dissimilar grading systems [12,27,38–40], differences in surgical technique, failure to distinguish between patients with single and multiple surgeries, and differences in patient populations.

A number of series in the literature have suggested that patients with ankylosing spondylitis undergoing THA are particularly predisposed to form heterotopic ossification [6,8,10,11,18,41]. As a result of these reports, prophylaxis using perioperative radiation or oral medication (nonsteroidal antiinflammatory drugs) has become a routine protocol at many centers treating these patients. We believe that a thorough review of the literature shows that patients with ankylosing spondylitis undergoing primary THA are not necessarily predisposed to forming heterotopic ossification and that the notion has arisen as a result of a number of poorly controlled clinical reports on the subject (Table 6).

Results of this investigation do not support the notion that all patients with ankylosing spondylitis undergoing primary THA are particularly predisposed to forming heterotopic ossification. In fact, our results in patients who received no perioperative prophylaxis indicate that ankylosing spondylitis patients have a significantly lower rate of heterotopic bone formation than patients with other diagnoses that have not traditionally been considered at high risk. In this investigation, 6 of 14 hips (43%) in patients with ankylosing spondylitis formed heterotopic ossification as compared with 43 of 49 hips (88%) in control subjects with other diagnoses. Furthermore, no hip in the ankylosing spondylitis group formed clinically important ossification (class III or IV) as compared with 6 of 49 hips (12%) in the control group.

Other authors studying heterotopic bone formation following THA have shown results similar to ours. Kilgus et al. reported the results of 55 THAs in 31 patients with ankylosing spondylitis who received no perioperative prophylaxis for heterotopic ossification [7]. At an average follow-up period of 76 months, 11% of their hips had formed class III or IV heterotopic bone, but all of these cases were in patients who had had complete ankylosis before surgery, prior surgery to the hip, or a postoperative infection. The authors concluded that "after total hip arthroplasty, a clinically important amount of heterotopic bone does not develop more frequently in patients who have ankylosing spondylitis compared with those who have osteoarthrosis." DeLee et al. studied ectopic bone formation in 2,173 cases following low-friction arthroplasty of the hip [13]. The prevalence of ectopic bone formation was 6% in their patients with ankylosing spondylitis, which was actually the lowest of all diagnostic groups studied. The prevalence of ectopic bone formation in the other diagnostic groups were osteoarthritis, 16%; congenital dislocation, 12%; Legg–Calve–Perthes disease, 15%; rheumatoid arthritis, 11%; slipped capital femoral epiphysis, 11%; idiopathic protrusio, 9%; and Paget's disease, 9%. Similarly, Ritter and Vaughan performed a statistical analysis on 507 THAs to identify factors predisposing to heterotopic bone formation [16]. The overall prevalence of heterotopic bone formation in patients with ankylosing spondylitis was 42% and was Hamblen [39] grade I (less than one third of the area about the hip involved in the process of forming heterotopic bone) in all cases. This prevalence in ankylosing spondylitis was not significantly different when compared with the prevalence of heterotopic bone formation in 12 other diagnostic groups reported. Finally, Giordani et al. reported their results of 25 THAs in 22 patients with ankylosing spondylitis at an average follow-up period of 4.6 years [14]. Of the 25 cases, only 1 hip (4%) formed heterotopic ossification, and the authors concluded that "patients with ankylosing spondylitis are at comparable risk for heterotopic ossification as the general population and special prophylaxis precautions need not be taken."

Inasmuch as we have shown that patients with ankylosing spondylitis undergoing primary THA are not particularly predisposed to forming heterotopic bone, we believe that routine prophylaxis is not warranted and should not be performed. Although perioperative irradiation has been shown to be effective in preventing heterotopic ossification in high-risk patents [15,19–21,23,42,43], it has also been shown to decrease the strength of fixation of porous-coated implants [44–46] and to increase the incidence of nonunion in cases performed with a trochanteric osteotomy [21].

A further concern that has received little attention is the theoretical risk of malignancy and anemia following radiation in patients with ankylosing spondylitis [47]. Although the total dosage of radiation currently employed for prophylaxis following THA is relatively [47] small, and the current techniques using limited radiation fields are relatively [47] safe, we do not believe the risks associated with radiation, regardless of how small, are justified for patients with ankylosing spondylitis undergoing primary THA because they do not appear to be at increased risk for forming heterotopic bone. Similarly, we do not believe that the potential benefits of prophylactic nonsteroidal

Table 6. Critical Review of the Body of Literature That Has Suggested That Patients With Ankylosing Spondylitis Undergoing THA Are Particularly Predisposed to Forming Heterotopic Bone

Study/Year	Number of Patients With Ankylosing Spondylitis	Number of THAs	Prevalence of Heterotopic Bone Formation	Potential Confounding Variables and Limitations of the Study
Wilde et al. [41]/1972	1 (case report)	1 (case report)	100%	Preoperative ankylosis Prior surgery (cup arthroplasty) Trochanteric osteotomy
Bisla et al. [6]/1976	23	34	62%	12 hips had preoperative bony ankylosis 9 hips had preoperative fibrous ankylosis 10 hips had had prior surgery 34 hips had a trochanteric osteotomy 1 hip had a postoperative infection
Resnick et al. [8]/1976	11	21	57%	9 of 10 hips with a history of prior surgery formed heterotopic bone versus heterotopic bone formation in only 3 of 11 hips with no prior surgery
Taylor et al. [18]/1976	—*	70	9%	The authors compared the rates of heterotopic bone formation in patients with ankylosing spondylitis, osteoarthritis, and rheumatoid arthritis but failed to perform a statistical analysis Although the rate of heterotopic bone was only 9% in patients with ankylosing spondylitis, the authors concluded that these patients are particularly predisposed to forming heterotopic bone
Sundaram and Murphy [17]/1986	66	98	40%	The prevalence of heterotopic bone formation was 63% in hips having a trochanteric osteotomy and 55% in hips with a history of prior surgery
Toni et al. [10]/1987	—*	28	50% (21% Brooker class III or IV)	8 hips had a trochanteric osteotomy 12 hips had preoperative ankylosis Some hips were revision hip arthroplasties
Walker and Sledge [11]/1991	19	29	77%	10 hips had a trochanteric osteotomy 3 hips had had prior surgery 3 hips had preoperative ankylosis

*Data unavailable.

antiinflammatory drug administration [48] justify the possible associated complications (gastrointestinal, renal, etc.) in these patients who are at no increased risk of forming heterotopic bone.

Conclusion

Noncemented primary THA is an acceptable treatment option for the patient with ankylosing spondylitis and advanced symptomatic hip disease. In this investigation, our patients showed a significant improvement in pain intensity, function, and range of motion following noncemented THA. Heterotopic ossification was observed significantly less frequently in these patients than in a control group of our patients with osteoarthritis, osteonecrosis, rheumatoid arthritis, and post-traumatic arthritis. The use of routine perioperative prophylaxis for heterotopic ossification does not appear to be warranted in all patients with ankylosing spondylitis undergoing routine primary noncemented THA.

Acknowledgments

The authors thank Rebecca Trahan and Gretchen Schultz for their assistance in the preparation of the manuscript.

References

1. Forouzesh S, Bluestone R: The clinical spectrum of ankylosing spondylitis. Clin Orthop 143:53, 1979
2. Forestier J, Jacqueline F, Rotes-Carl JR: Involvement of peripheral joints. p. 128. In Forestier J, Jacqueline F, Rotes-Carl JR (eds): Ankylosing spondylitis: clinical considerations, roentgenology, pathologic anatomy, treatment, Charles C. Thomas/Bannerstone House, Springfield, IL, 1951
3. Wordsworth BP, Mowat AG: A review of 100 patients with ankylosing spondylitis with particular reference to socio-economic effects. Br J Rheumatol 25:175, 1986
4. Arden GP, Ansell MB, Hunter MJ: Total hip replacement in juvenile chronic polyarthritis and ankylosing spondylitis. Clin Orthop 84:130, 1972
5. Baldursson H, Brattstrom J, Osson TH: Total hip replacement in ankylosing spondylitis. Acta Orthop Scand 48:499, 1977
6. Bisla RS, Ranawat CS, Inglis AE: Total hip replacement in patients with ankylosing spondylitis with involvement of the hip. J Bone Joint Surg 58A:233, 1976
7. Kilgus DJ, Namba RS, Gorek JE et al: Total hip replacement for patients who have ankylosing spondylitis: the importance of formation of heterotopic bone and of the durability of fixation of cemented components. J Bone Joint Surg 72A:834, 1990
8. Resnick D, Dwosh IL, Goergen TG et al: Clinical and radiographic "reankylosis" following hip surgery in ankylosing spondylitis. AJR 126:1181, 1976
9. Shanahan WR, Kaprove RE, Major PA et al: Assessment of longterm benefit of total hip replacement in patients with ankylosing spondylitis. J Rheumatol 9:101, 1982
10. Toni A, Baldini N, Sudanese A et al: Total hip arthroplasty in patients with ankylosing spondylitis with a more than two year follow-up. Acta Orthop Belg 53:63, 1987
11. Walker LG, Sledge CB: Total hip arthroplasty in ankylosing spondylitis. Clin Orthop 262:198, 1991
12. Williams E, Taylor AR, Arden GP, Edwards DH: Arthroplasty of the hip in ankylosing spondylitis. J Bone Joint Surg 59B:393, 1977
13. Turula K, Savioja S, Innes A, Hamalainen M: Early results of cementless total hip replacement in inflammatory joint disease: the Rheumatism Foundation experience. Scand J Rheumatol 67:61, 1988
14. Giordani M, Penenberg BL, Kaufman RL: Heterotopic ossification following total hip arthroplasty in patients with ankylosing spondylitis. p. 52. In Program of the instructional course lectures: the American Academy of Orthopaedic Surgeons. CV Mosby, St. Louis, 1989
15. Healy WL, Lo TCM, Covall DJ et al: Single-dose radiation therapy for prevention of heterotopic ossification after total hip arthroplasty. J Arthroplasty 5:369–375, 1990.
16. Ritter MA, Vaughan RB: Ectopic ossification after total hip arthroplasty. J Bone Joint Surg 59A:345, 1977
17. Sundaram NA, Murphy JCM: Heterotopic bone formation following total hip arthroplasty in ankylosing spondylitis. Clin Orthop 207:223, 1986
18. Taylor AR, Kamdar BA, Arden GP: Ectopic ossification following total hip replacement. J Bone Joint Surg 58B:134, 1976
19. Ayers DC, Evarts CM, Parkinson JR: The prevention of heterotopic ossification in high-risk patients by low-dose radiation therapy after total hip arthroplasty. J Bone Joint Surg 68A:1423, 1986
20. Coventry MB, Scanlon PW: The use of radiation to discourage ectopic bone: a nine-year study in surgery about the hip. J Bone Joint Surg 63A:201, 1981
21. MacLennan I, Keys HM, Evarts CM, Rubin P: Usefulness of postoperative hip irradiation in the prevention of heterotopic bone formation in a high risk group of patients. Int J Radiat Oncol Biol Phys 10:49, 1984
22. Parkinson J, Evarts CM: Heterotopic bone formation after total hip arthroplasty. Adv Orthop Surg 8:18, 1984
23. Pellegrini VD, Konski AA, Gastel JA et al: Prevention of heterotopic ossification with irradiation after total hip arthroplasty. J Bone Joint Surg 74A:186, 1992
24. Moll JMH, Wright V: New York criteria for ankylosing spondylitis: a statistical evaluation. Ann Rheum Dis 32:354, 1973
25. Brinker MR, Lund PJ, Cox DD, Barrack RL: Demographic biases found in scoring instruments of total hip arthroplasty. J Arthroplasty 11:820, 1996
26. Federal poverty income guidelines for fiscal year 1993. Federal Registry, p. 5455, Feb. 12, 1992
27. Brooker AF, Bowerman JW, Robinson RA, Riley LH: Ectopic ossification following total hip replacement: incidence and a method of classification. J Bone Joint Surg 55A:1629, 1973
28. Harris WH: Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty. An end-result study using a new method of result evaluation. J Bone Joint Surg 51A:737, 1969
29. Brinker MR, Rosenberg AG, Kull L, Galante JO: Primary total hip replacement using noncemented porous coated femoral components in patients with osteonecrosis of the femoral head. J Arthroplasty 9:457, 1994
30. Martell JM, Pierson RH, Jacobs JJ et al: Primary total hip reconstruction with a titanium fiber-coated prosthesis inserted without cement. J Bone Joint Surg 75A:554, 1993
31. Gruen TA, McNeice GM, Amstutz HC: "Modes of failure" of cemented stem-type femoral components: a radiographic analysis of loosening. Clin Orthop 141:17, 1979
32. Johnston RC, Fitzgerald RH Jr, Harris WH et al: Clinical and radiographic evaluation of total hip replacement: a standard system of terminology for reporting results. J Bone Joint Surg 72A:161, 1990

33. Haddad RJ, Cook SD, Brinker MR: A comparison of three varieties of noncemented porous-coated hip replacements. J Bone Joint Surg 72B:2, 1990
34. Calin A, Elswood J: The outcome of 138 total hip replacements and 12 revisions in ankylosing spondylitis: high success rate after a mean follow-up of 7.5 years. J Rheumatol 16:955, 1989
35. Halley DK, Charnley J: Results of low friction arthroplasty in patients thirty years of age or younger. Clin Orthop 112:180, 1975
36. Welch RB, Charnley J: Low-friction arthroplasty of the hip in rheumatoid arthritis and ankylosing spondylitis. Clin Orthop 72:22, 1970
37. Kull LR, Tomkins GS, Silverton CD, Galante JO: Primary cementless acetabular reconstruction: osteolysis and interface changes at seven and ten year follow-up. Presented at the 62nd Annual Meeting of the American Academy of Orthopaedic Surgeons, Orlando, FL, February 1995
38. DeLee J, Ferrari A, Charnley J: Ectopic bone formation following low friction arthroplasty of the hip. Clin Orthop 121:53, 1976
39. Hamblen DL, Harris WH, Rottger J: Myositis ossificans as a complication of hip arthroplasty. J Bone Joint Surg 53B:764, 1971
40. Riegler HF, Harris CM: Heterotopic bone formation after total hip arthroplasty. Clin Orthop 117:209, 1976
41. Wilde AH, Collins HR, Mackenzie AH: Reankylosis of the hip joint in ankylosing spondylitis after total hip replacement. Arthritis Rheum 15:493, 1972
42. Hedley AK, Mead LP, Hendren DH: The prevention of heterotopic bone formation following total hip arthroplasty using 600 rad in a single dose. J Arthroplasty 4:319, 1989
43. Maloney WJ, Jasty M, Willett C et al: Prophylaxis for heterotopic bone formation after total hip arthroplasty using low-dose radiation in high-risk patients. Clin Orthop 280:230, 1992
44. Konski A, Weiss C, Rosier R et al: The use of postoperative irradiation for the prevention of heterotopic bone after total hip replacement with biologic fixation (porous coated) prosthesis: an animal model. Int J Radiat Oncol Biol Phys 18:861, 1990
45. Sumner DR, Turner TM, Pierson RH et al: Dose and time-dependent effects of radiation treatment of early bone ingrowth in a canine model. Poster exhibit at the 35th Annual Meeting of the Orthopaedic Research Society, Las Vegas, NV, February 1989
46. Wise MW, Robertson ID, Lachiewicz PF et al: The effect of radiation therapy on the fixation strength of an experimental porous-coated implant in dogs. Clin Orthop 261:276, 1990
47. Court-Brown WM, Doll R: Mortality from cancer and other causes after radiotherapy for ankylosing spondylitis. BMJ 2:1327, 1965
48. Ritter MA, Sieber JM: Prophylactic indomethacin for the prevention of heterotopic bone formation following total hip arthroplasty. Clin Orthop 196:217, 1985