Mod Rheumatol (2002) 12:219–225

ORIGINAL ARTICLE

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Total hip arthroplasty with bone graft for acetabular protrusion in rheumatoid arthritis

Received: September 21, 2001 / Accepted: February 1, 2002

Abstract Twenty-five hips in 19 rheumatoid arthritis (RA) patients with protrusio acetabuli were followed up, both clinically and radiographically, for more than 9 years after total hip arthroplasty (THA), that was performed with a bone graft to reinforce the medial acetabular wall. Radiographs were taken preoperatively and every 6 months postoperatively. Clinical assessments of pain, gait, and range of motion of the hips were obtained preoperatively and every year postoperatively using the Japanese Orthopaedic Association hip-scoring system. Radiographs showed that bony union had occurred in all cases. Six acetabular components were loose, but no femoral components became loose during the 9-year period. The clinical evaluation showed that relief of pain was very significant. The range of motion of the hip joints also improved from 12 points to 16.6 points after 9 years. Walking ability improved, but is becoming worse as time goes by. The radiographic results were compared with the results of a THA group with RA that had not had a bone graft. The rate of loosening of the THA without a bone graft was significantly higher than that of THA with a bone graft. We concluded that bone grafting for protrusio acetabuli was a very useful procedure.

Key words Acetabular protrusion · Bone graft · Rheumatoid arthritis (RA) · Total hip arthroplasty (THA)

Introduction

Secondary protrusio acetabuli occurs in many disease states, including rheumatoid arthritis (RA), ankylosing spondylitis, osteomalacia, rickets, osteoporosis, Paget's disease, trauma, and so on. Protrusio acetabuli can often be seen in hips with RA. Painful and progressive protrusio acetabuli should be treated by total hip arthroplasty (THA). The stability of the socket is a concern after the arthroplasty because of poor bone quality or cortical bone defects. Therefore, the long-term clinical and radiographic results after conventional THA for protrusio acetabuli may not always be successful. Methods have been developed to improve the fixation of the acetabular prosthesis to correct protrusio acetabuli. Special shells, metal rings, protrusio sockets, and other apparatus have been developed to redistribute stresses from the deficient medial wall to the outer rim of the acetabulum.

If the defect in the acetabular wall is small, these methods are not used. We only use autogenous bone grafts from the resected femoral neck and head to reinforce the medial acetabular wall when performing THA. This article describes the method of grafting the acetabular wall with a solid piece of femoral neck and head used at Nagoya National Hospital. The results of our series of 25 hips with a minimum 9-year follow-up period are presented clinically and radiographically. The aim of this study was to evaluate whether autogenous bone grafts to the medial wall will fuse in place radiographically, and to assess the results of THA with this procedure clinically and radiographically. In addition, the results from a group of RA patients with protrusio acetabuli who underwent THA without a bone graft were compared with the results of this series.

Materials and methods

From January 1971 to December 2000, about 560 THAs were performed in 370 patients with RA at Nagoya National Hospital. Of the 560, 120 were in hips with protrusio acetabuli. From January 1982 to December 1991, 36 THAs were performed by the same operating team using cement and bone grafts in 28 patients who had painful, progressive protrusio acetabuli. Twenty-five hips in 19 patients were available for this study. Seven patients (8 hips) died and 2 patients (3 hips) lost contact within the 9 years

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following operation. The average follow-up period was 129.6 months (range 108–178 months). Of the 19 patients, 3 were men and 16 were women. The average age at operation was 56.7 years (range 42–73 years). The type of implant was Bioceram, Kyocera, Japan, in all cases. Bone cement was used in all cases, and an acetabular support ring in three cases. All patients in this series were followed up by the authors of the paper, both with routine examinations according to the Japanese Orthopaedic Association (JOA) hip-scoring system and with radiographs taken every 6 months after the operation.

Radiographic evaluation

The radiographs were taken preoperatively and every 6 months postoperatively. In the radiological assessment of protrusio acetabuli, the amount of protrusio was measured according to the grading system of Sotelo-Garza and Charnley.[1] With these methods, the amount of protrusio acetabuli was graded as: grade 1, 1–5 mm; grade 2, 6–15 mm; grade 3, more than 15 mm. According to this system, 8 hips were grade 1, 13 were grade 2, and 4 were grade 3.

Radiolucent lines between bone and bone cement were measured in the radiographs taken every 12 months postoperatively. The radiolucencies of the acetabular sites were separated into five stages:[2] stage 0, no radiolucency; stage I, the width of the radiolucent line was less than 2 mm, and the length of the radiolucency was less than one-third of the circumference; stage II, the width of the radiolucent line was more than 2 mm, and the length of the radiolucency was more than one-third of the circumference; stage III, preloosening; stage IV, loosening or fractured cement.

Clinical evaluation

The clinical assessments of pain, walking ability, and range of motion (ROM) of the hip joints were obtained preoperatively and every year postoperatively using the JOA hip-scoring system (Table 1). The activities of daily life were excluded from clinical evaluations because RA patients have some involvement of not only hips, but also knees, ankles, feet, and so on. Therefore, we cannot evaluate the activities of daily life simply by the improvement in the function of the hip joint.

Comparison with the group of protrusio acetabuli patients without a bone graft (Table 2)

Before 1982, we did not use a bone graft at Nagoya National Hospital when total hip arthroplasties were performed in RA patients with protrusio acetabuli. Therefore, we wished to evaluate whether the bone grafting is useful for treating protrusio acetabuli. The results of the group with a bone graft (this series, BG group) were compared radiographically with a group without a bone graft (NG group). From January 1971 to December 1981, 37 total hip arthroplasties without a bone graft were performed in 30 patients with protrusio acetabuli. Twenty-two hips in 20 patients (2 men, 18 women) were available for this study. Seven patients (10 hips) died and 3 patients (5 hips) lost contact within the 9 years following the operation. The average age at the operation was 57.8 years. The average follow-up period was 151.3 months (range 108–310 months).

Table 1. Evaluation chart of hip joint funcitons by the Japanese Orthopaedic Association hip-scoring system

A. Pain: 0–40 points	
None	40
Slight	30
Moderate	20
Severe	10
Unbearable	0
B. Range of motion: 0–20 points[a]	
Flexion	0–12
Abduction	0–8
C. Ability to walk: 0–20 points	
Normal	20
Slight limp	15
Severe limp	10
Difficult to walk	5
Impossible	0

[a] Scores are determined by multiplying 30 degrees of motion in each arc by 3 points in flexion, and 10 degrees of motion in each arc by 2 points in abduction

Table 2. Comparison with the group of protrusio acetabuli patients without a bone graft

	Average age at operation (years); sex	Follow-up period (months)	Grading of protrusio acetabuli
With bone graft (25 joints in 19 patients)	56.7 Male 3 Female 16	129.6 (108–178)	Grade 1, 8 Grade 2, 13 Grade 3, 4
Without bone graft (22 joints in 20 patients)	57.8 Male 2 Female 18	151.3 (108–310)	Grade 1, 8 Grade 2, 10 Grade 3, 4

Surgical technique

The use of a bone graft should be considered in all cases of protrusio acetabuli. The femoral neck and head are a good source for the graft. One or two thin slices of the femoral neck (about 2–5 mm thick) are taken while resecting the femoral heads. The cancellous bone is taken from the resected head and cut into fine chips. Then the acetabulum is prepared using a reamer, a surgical airtome, and curettage. It is not necessary to deepen it with the reamer because the wall of the acetabulum is already thin and dislocated medially. The removal of soft tissue and cartilage is all that is necessary.

After preparing the acetabulum, soft tissue and sclerotic cortical bone are removed from the graft, and the sliced bones are placed against the medial or cranial wall of the acetabulum as closely as possible. They are hammered firmly into place using the butt end of a Charnley acetabular

pusher, which molds them against the sides of the acetabulum to obtain a firm fit. Then the prosthesis is tried to make sure that the graft is not too thick. Any gaps between the graft and the acetabular bed must be filled with fine bone chips to prevent ingress of cement. This procedure is very important because the bone cement may hinder bone fusion. Furthermore, the use of fibrin glue can help to seal off the margin of the bone graft and prevent cement seepage under the graft. Anchor holes for the cement should be drilled into the acetabular wall and not the graft. The socket should be fixed with bone cement in all cases. When the medial wall is very thin and weak, the acetabular support ring can be considered (Fig. 1).

Results

Radiographic assessment

Radiographs showed that bony union had occurred in all cases. No radiolucent line had appeared around the femoral component in any case 9 years postoperatively. As for the acetabular component, 6 cases (24%) had no radiolucency, 13 cases were stage I (52%), 2 were stage II (8%), and 1 was stage III (4%) 5 years postoperatively (Fig. 2). Three acetabular components became loose (stage IV, 12%) within 5 years. Nine years postoperatively, 5 cases were stage 0 (20%), 11 were stage I (44%), 3 were stage II (12%), and 6 were stage IV (24%) (Fig. 2). Of the 6 stage IV cases, 3 cases were grade 3 and 3 were grade 2 preoperatively according to Charnley's grading system. There were no grade 1 cases preoperatively.

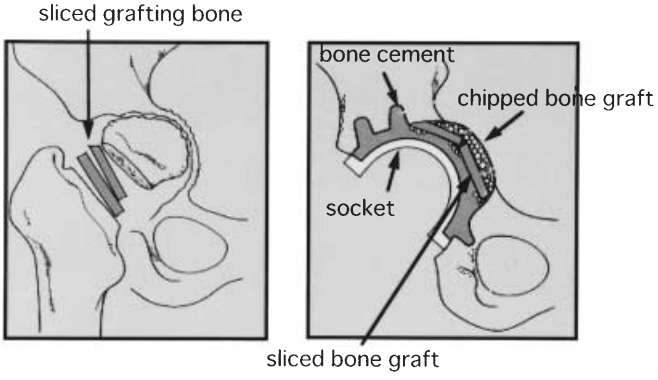

Fig. 1. Surgical technique. A cross section showing the defect, the grafted bone, bone cement, and the polyethylene socket

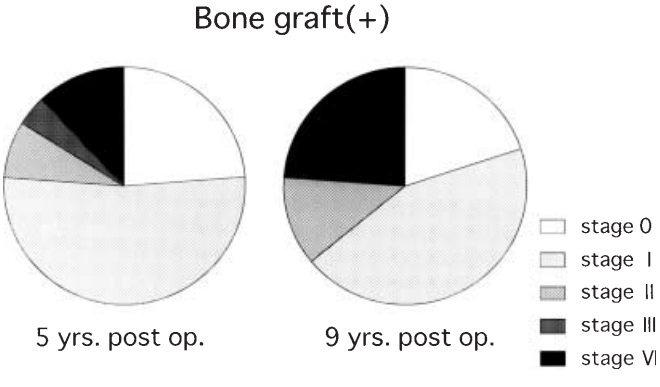

Fig. 2. Radiographic assessment of the protrusio acetabuli group with a bone graft

Clinical findings

The clinical findings were evaluated using the JOA hip-scoring system. Relief of pain was significant and continuous after 9 years (Fig. 3). The average pain score had improved from 19.6 to 38 points after 5 years, and was 35.2 points after 9 years. The range of motion of the hip joints also improved from 12 to 16.5 points after 5 years, and to 16.6 points after 9 years. Walking ability had improved from 7.2 to 11 points 5 years after the operation, but then it gradually became worse (9.4 points after 9 years).

Comparisons with the group of protrusio acetabuli without a bone graft (NG group)

According to the grading system of Sotelo-Garza and Charnley, eight hips in the NG group were grade 1, ten were grade 2, and four were grade 3. In all cases, bone defects due to protrusio acetabuli were covered with bone cement. Five cases were stage 0 (22.7%), five were stage I (22.7%), six were stage II (27.4%), three were stage III (13.6%), and three were stage IV (13.6%) 5 years postoperatively (Fig. 4). Nine years postoperatively, three cases were stage 0 (13.6%), four were stage I (18.2%), six were stage II (27.3%), three were stage III (13.6%), and six were stage IV (27.3%). The incidence of stage II was significantly higher in the NG group, and about 70% of cases were stage 0 or stage I in the BG group after 5 years. After 9 years, the failure rate (stage III and stage IV) in the NG group was significantly higher than in the BG group.

Case reports

Case 1 (Fig. 5)

A 60-year-old woman with a 20-year history of RA (stage IV, class 3) noticed the onset of left hip pain in 1986. Over the next 3 years she developed a waddling gait, severe left hip pain, and marked left protrusio acetabuli (grade 1) (Fig. 5a). In 1989 she underwent total left hip replacement. Her initial postoperative course was satisfactory, with complete relief of pain and a return to nearly normal gait. Her JOA hip score improved from 48 preoperatively to 78 points postoperatively. A radiograph 6 months after the operation

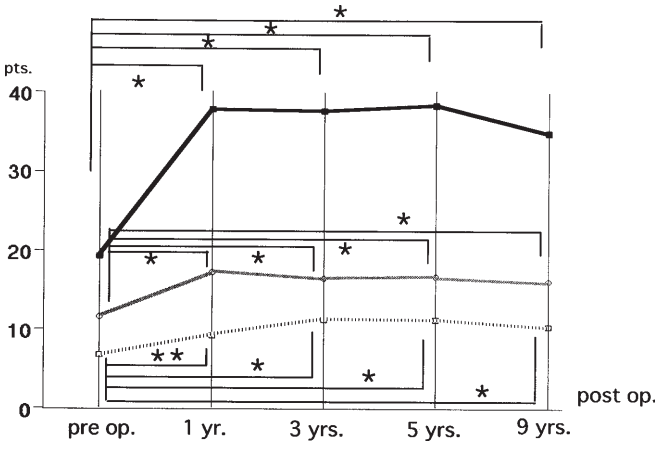

Fig. 3. Clinical findings. Hip pain, walking ability, and range of motion (*ROM*) of the hip joint were evaluated by the Japanese Orthopaedic Association hip-scoring system. *Black line*, pain; *gray line*, ROM; *dotted line*, gait. * $P < 0.01$; ** $P < 0.05$

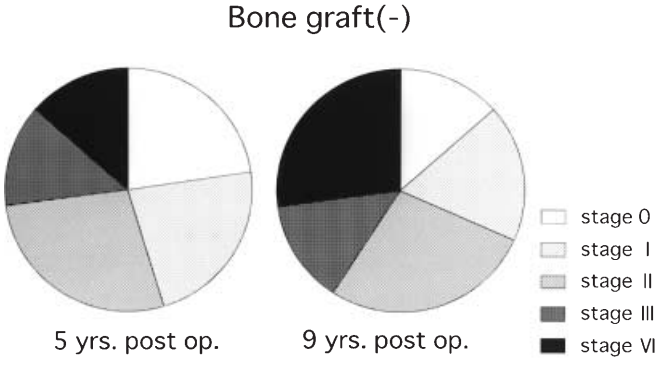

Fig. 4. Radiographic assessment of the protrusio acetabuli group without a bone graft

showed that the bone graft had completely fused (Fig. 5b). After 10 years she has no left hip pain and a radiograph showed no radiolucency (Fig. 5c).

Case 2 (Fig. 6)

In 1984, a 45-year-old man with a 12-year history of RA (stage IV, class 2) complained of moderate pain in his left hip. A radiograph showed virtually normal hips at that time. Over the next 2 years he developed a severe left hip pain and a marked limp. A radiograph revealed a left protrusio acetabuli (grade 3) (Fig. 6a). In 1986, he underwent total left hip replacement with bone grafting of the medial wall. After 1 year, a radiograph showed that the grafting bone had fused (Fig. 6b) and his JOA hip score had improved remarkably from 43 points preoperatively to 76 points postoperatively. After 5 years, a radiograph showed radiolucency but he had no left hip pain. After 7 years, a radiograph revealed that there was a radiolucent line around the socket, which had loosened (Fig. 6c), but he had no hip pain and could walk without cane. We are still following up on him carefully.

Discussion

Since Otto first described deformity of the acetabulum in 1824, protrusio acetabuli has been common in RA. In such cases, it is very difficult to treat the weakness in the medial wall of the acetabulum. Therefore, we are concerned about the long-term results of THA in protrusio acetabuli. The deficient bone stock of the acetabulum in RA patients may increase the risk of further migration and the rate of loosening of the socket.

We first discuss how to deal with the weakness or defect in the medial wall. In other words, whether a bone graft or cement should be used when performing a hip arthroplasty for protrusio acetabuli.

Sotelo-Garza and Charnley[1] described a case of protrusio acetabuli that had not become worse after THA even though it was performed without a bone graft. They therefore reported that there was no need for a bone graft or metal reinforcement for successful results.

On the other hand, McCollum et al.[3] reported that methylmethacrylate or protrusio acetabuli appliances alone might eventually fail in the absence of good bone stock, and should be supplemented with a bone graft to provide lasting support. When filling with a large amount of bone cement, it is difficult to fix the socket in the correct position. They reported no improvement in the condition of the thin friable acetabular wall. Eventually the socket fused with the mass of bone cement and moved centripetally, destroying the pelvic bone.

Ranawat et al.[4] reviewed a series of protrusio acetabuli reconstructed without the use of a bone graft. They found a high incidence of grade 3 radiographic cement–bone interface demarcation in hips in which the component was positioned 1 cm medially or superiorly beyond the anatomical position. Therefore, Ranawat and Zahn[5] recommended that if the protrusio was greater than 5 mm, an autogenous bone graft should be used. Other authors also suggested that bone grafting might be helpful in treating acetabular protrusion.[6–8]

The use of the excised femoral head to fill the acetabular defect has recently gained impetus.[9] Crowninshield et al.[10] reported that in cases of successful acetabular grafting, the stress on the medial pelvic wall was lower. Bayley et al.[11] reported the benefit of bone grafting compared with augmentation with cement alone at an average of 3.7 years postoperatively. Stauffer[12] reported that bone grafting was thought to reduce the incidence of loosening of components. In our series, the results of THA for protrusio acetabuli using an autogenic bone graft and cement were satisfactory. There was a significant difference in the results for groups of patients with or without a bone graft. We concluded that bone grafting was indispensable in treating protrusio acetabuli.

We now consider the source of the graft bone. We can obtain graft bone from the resected femoral neck and head. Some other teams have taken grafts from the femoral head, iliac crest, and allogenic bone.[3,5,13] These methods might carry some risk of new invasion and infection. McCollum et

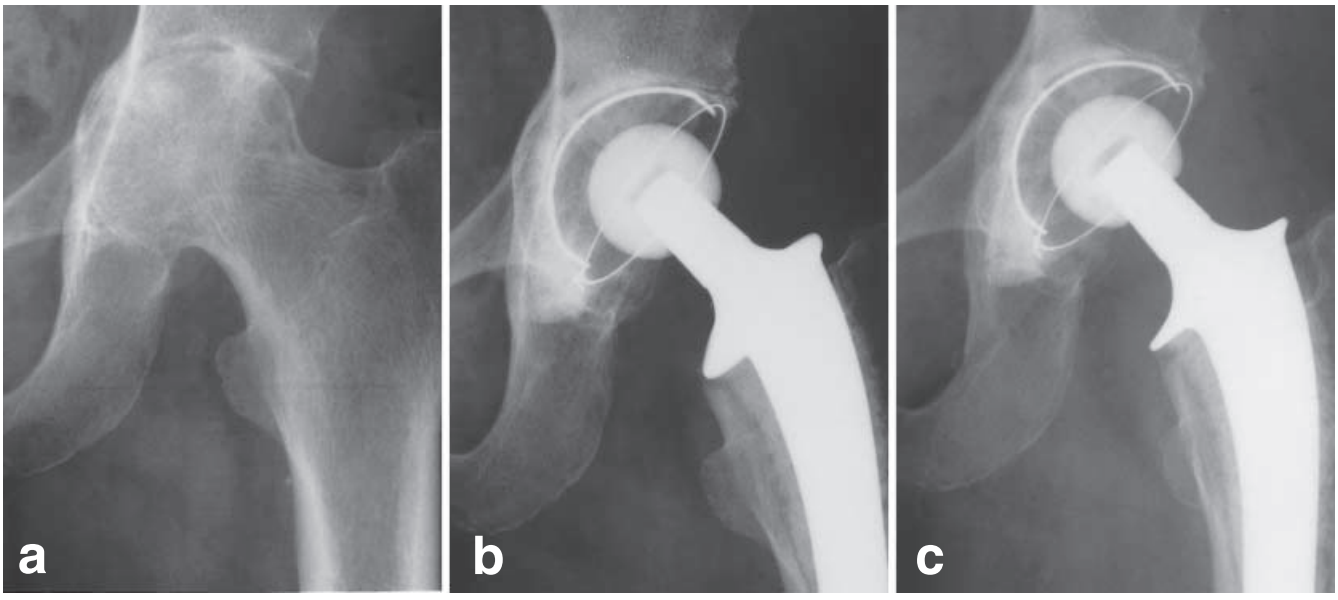

Fig. 5a–c. Case 1. **a** Preoperative radiograph of the left hip showing moderate protrusio acetabuli. **b** The grafted bone in the acetabulum fused completely 6 months after the operation. **c** Radiograph 10 years after the operation showing no radiolucency

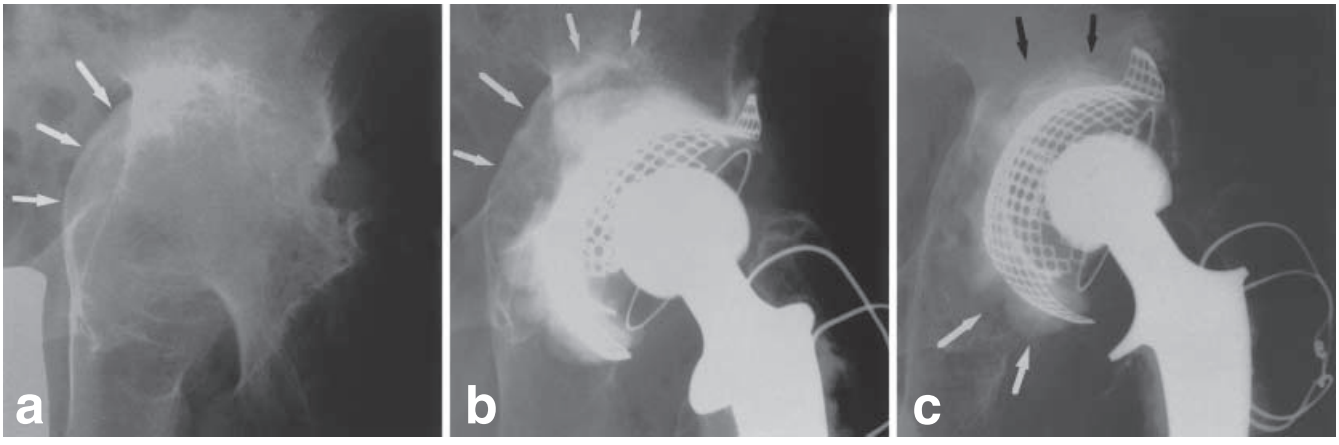

Fig. 6a–c. Case 2. **a** Preoperative radiograph of the left hip showing severe protrusio acetabuli (*arrows*). **b** Total hip arthroplasty performed with a bone graft and a metal mesh acetabular supporter. Radiograph 1 year after the operation, showing that the grafted bone had fused (*arrows*) and the socket and stem were well fixed. **c** Radiograph 7 years after the operation, showing that the grafted bone had collapsed (*black arrows*) and the socket had loosened (*white arrows*)

al.[3] reported that there were no differences in the time until graft incorporation among patients with autogenous femoral head or iliac crest grafts, or homologous backbone grafts. We therefore recommend resected femoral neck and head bone grafts.

We now discuss the type of grafting bone. Various methods of bone grafting have been reported.[3,5,8,14,15] The type of bone varied from solid bone to spongious chip bone. Good results have been obtained with all types of bone graft. Johnsson et al.[8] reported that THA using autogenous spongious bone chips to reinforce the medial wall was a successful surgical procedure in patients with acetabular protrusion. In 25 hips out of 26, radiographs showed that the bone grafts had healed and no further protrusion occurred. Heywood[14] reported that conditions favorable to the incorporation of a graft were almost perfect when the cancellous graft was in the form of a solid block, rather than when it was in the form of chips, shaves, or ribbons. We have used both solid bone and chip bone grafts. Solid bone grafts were used to reinforce a deficient medial wall or acetabular wall, and chip bone grafts were used to fill the gaps between the solid bone graft and the acetabular bed. Fortunately, in all these cases the grafted bone fused within an average time of 7 months.[16]

We also concluded that methylmethacrylate was necessary for treating protrusio acetabuli because it took several months for the grafted bone to fuse with the acetabular bed. Until the grafted bone fuses, it is necessary to prevent collapse or resorption.

If the medial wall is found to be grossly deficient, it should be reconstructed with a bone graft as well as an acetabular support ring or other fixation device. To prevent further protrusion, many methods to reinforce the acetabular medial wall have been reported. Appliances to redistribute the patient's weight and enhance the strength of the medial wall were devised by Harris and Jones,[17] Hasting and Parker,[7] and others.[18,19] Harris and Jones used wire mesh. Hasting and Parker developed a molded coarse vitallium-mesh cup. In this series, we used an acetabular cup support in three cases only. We now use a Kerboull cross-shell in such cases.[18]

The clinical assessments revealed that the relief of pain was very significant. Many of the patients (80%) had no hip pain after THA. The range of motion of the hip joints was also improved. We concluded that THA with a bone graft for protrusio acetabuli was a durable procedure for the relief of pain and improved ROM. Walking ability had also improved after the operation, but it got worse as time went by. The reason was that almost all patients in this series had either involvement of the opposite hip or involvement of the knees, ankles, or feet. Therefore, a hip arthroplasty only was not enough to improve and maintain walking ability.

The radiographic results in this series showed that all grafts appeared to have united to the acetabular wall within 7 months. The failure rate in our series was 16% (four hips) at 5 years after the operation, and 24% (six hips) at 9 years. Gates et al.[13] showed that the rate of definite loosening of the acetabular component was 20% at an average of 12.8 years after the operation, and the rate of loosening and revision were similar to those in patients who did not have protrusio acetabuli. In the studies of Stauffer[12] and of Sutherland et al.,[20] the rates were 10% and 30%, respectively. The failure rate in our series was similar to those reported in other studies. Of course, these long-term results are affected by the RA activity after surgery. It is essential that medicinal treatment to control the RA activity is continued.

In order to decrease the failure rate, we need to improve the surgical techniques. We should first improve the methods of bone grafting. Although bone grafting is useful and necessary in the treatment of protrusio acetabuli, it is very important to gain complete bone union for successful results.

When using bone cement, it is very important to ensure that cement does not leak into the grafted bone. Any gaps between the graft and the acetabular bed must be filled with fine bone chips to prevent the ingress of cement. This is essential for the revascularization between the bone graft and the acetabular base. Recently, fibrin glue has been used to get a good contact between the grafted bone and the acetabular base. This method made sure that the grafted bone was not displaced when the bone cement was used, and prevented leakage of the bone cement.[21] The cementing technique, e.g., pressurization, is another very important factor. Pressing the bone cement onto the acetabulum, as in our series, may not be enough. For good results, it is necessary to improve the bone cement pressurization technique.[22]

In the preparation of the acetabular site, synovial tissue or any soft tissue should be removed with a reamer, a surgical airtome, and curettage. If any synovial tissue or soft tissue remains on the acetabular base, revascularization between the bone graft and the acetabular base will be prevented.

Damron and Heiner[23] reported the existence of rapidly progressive protrusio in the natural history of rheumatoid coxarthritis. Therefore, another very important factor is the timing of the operation, which should always be carried out as soon as possible before farther damage occurs.

References

1. Sotelo-Garza A, Charnley J. The results of Charnley arthroplasty of the hip performed for protrusio acetabuli. Clin Orthop 1978;132:12–8.
2. Uno M. Development of a clear zone after total hip replacement (in Japanese). J Jpn Orthop Assoc 1981;55:543–62.
3. McCollum DE, Nunley JA, Harrelson JM. Bone-grafting in total hip replacement for acetabular protrusion. J Bone Joint Surg 1980;62-A:1065–73.
4. Ranawat CS, Dorr LD, Inglis AE. Total hip arthroplasty in protrusio acetabuli of rheumatoid arthritis. J Bone Joint Surg 1980;62A:1059–65.
5. Rnawat CS, Zahn MA. Role of bone grafting in correction of protrusio acetabuli by total hip arthroplasty. J Arthroplasty 1986;1:131–7.
6. Salvati EA, Bullough P, Wilson PD. Intrapelvic protrusion of the acetabular component following total hip replacement. Clin Orthop 1975;111:212–27.
7. Hasting D, Parker S. Protrusio acetabuli in rheumatoid arthritis. Clin Orthop 1975;108:76–83.
8. Johnsson R, Ekelund L, Zygmunt S, Lidgren L. Total hip replacement with spongious bone graft for acetabular protrusion in patients with rheumatoid arthritis. Acta Orthop Scand 1984;55:510–3.
9. Harris WH, Crothers O, Oh I. Total hip replacement and femoral-head bone-grafting for severe acetabular deficiency in adults. J Bone Joint Surg Am 1977;59-A:752–9.
10. Crowninshield RD, Brand RA, Pedersen DR. A stress analysis of acetabular reconstruction in protrusio acetabuli. J Bone Joint Surg Am 1983;65-A:495–9.
11. Bayley JC, Christie MJ, Ewald FC, Kelly K. Long-term results of total hip arthroplasty in protrusio acetabuli. J Arthroplasty 1987;2:275–9.
12. Stauffer RN. Ten years follow-up study of total hip replacement. J Bone Joint Surg Am 1982;64-A:983–90.
13. Gates HS, McCollum DE, Poletti SC, Nunley JA. Bone-grafting in total hip arthroplasty for protrusio acetabuli. J Bone Joint Surg 1990;72A:248–51.
14. Heywood AWB. Arthroplasty with a solid bone graft for protrusio acetabuli. J Bone Joint Surg 1980;62-B:332–6.
15. Kinzinger PJM, Karthaus RP, Slooff TJJH. Bone grafting for acetabular protrusion in hip arthroplasty. Acta Orthop Scand 1991;62(20):110–2.
16. Kondo K, Asai T, Tsukamoto M. Total hip arthroplasty with bone graft for protrusio acetabuli in rheumatoid arthritis (in Japanese). J Musculoskeletal Syst 2000;13:523–30.
17. Harris WH, Jones WN. The use of wire mesh in total hip replacement surgery. Clin Orthop 1975;106:117–21.
18. Kerboull M. Acetabular and femoral reconstruction with allograft in bone stock loss following THR failures. Proceeding of the International Symposium. Charnley Total Hip Arthroplasty: 33 Years of World-Wide Experience; 1995; Lyon, p. 201–4.
19. Oh I, Harris WH. Design concepts, indications, and surgical technique for use of the protrusio shell. Clin Orthop 1982;162:175–84.
20. Sutherland CJ, Wilde AH, Borden LS, Marks KE. A ten-year follow-up of one hundred consecutive Mueller curved-stem total

hip-replacement arthroplasties. J Bone Joint Surg 1982;64A:970–82.
21. Saisho K, Ise K, Kuwahara S, Tajima N, Kimura C, Sugano T. Total hip replacement for protrusio acetabuli in rheumatoid arthritis with bone transplantation combined with fibrin glue. Jpn J Rheum 1994;5:237–42.
22. Madey SM, Callaghan JJ, Olejniczak JP, Goetz DD, Johnston RC. Charnley total hip arthroplasty with use of improved techniques of cementing. J Bone Joint Surg 1997;79A:53–64.
23. Damron TA, Heiner JP. Rapidly progressive protrusio acetabuli in patients with rheumatoid arthritis. Clin Orthop 1993;289:186–94.