Total Hip Arthroplasty in Protrusio Acetabuli: Ten Tips to Improve Surgical Outcomes

Protrusio acetabular en artroplastía total de cadera: diez tácticas para un buen resultado quirúrgico

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Abstract

Patients with acetabular protrusion and osteoarthritis are a challenge for the surgical team. Many strategies have been developed to anticipate, plan and optimize the surgical results of these patients. Based on the current available clinical evidence, we propose ten tips to improve the surgical management of hip arthroplasty patients with protrusio acetabuli.

Level of Evidence V.

Keywords

- protrusio acetabuli
- protrusio
- total hip arthroplasty
- THA

Resumen

Los pacientes candidatos a artroplastía total de cadera con protrusio acetabular asociada generan distintos desafíos en los equipos quirúrgicos. Múltiples estrategias han sido utilizadas a lo largo de los años para optimizar los resultados. Mediante una revisión de la evidencia actualizada disponible, proponemos diez tácticas a realizar en el manejo de estos pacientes que pueden mejorar y hacer predecible el tratamiento de un paciente con protrusio acetabular al que se le realiza una artroplastía total de cadera.

Nivel de Evidencia V.

Palabras clave

- protrusio acetabular
- protrusio
- artroplastía total de cadera
- ATC

Introduction

The acetabular deformity called acetabular protrusion, also known as protrusio acetabuli, arthrokatadysis, and Otto pelvis, occurs as the medial portion of the femoral head surpasses the ilioischial line. This deformity results in the medialization of the center of rotation (COR) of the hip, imposing some

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technical challenges to the procedure. Therefore, it is usually considered a "difficult" total hip replacement.

Surgeons must consider several anatomical features and patient-related particularities during the evaluation and treatment of acetabular protrusion. This narrative review describes ten surgical tips that may contribute in a succesful and reproducible outcome.

1. In patients with no underlying rheumatological diagnosis, should the acetabular protrusion be considered idiopathic and proceed with the surgery? Should the patient be studied prior to the surgery?

Acetabular protrusion is infrequent, and it may be primary (idiopathic) or secondary to several diseases, including rheumatological, infectious, and metabolic conditions (►**Table 1**). Patients with no previous rheumatological diagnosis, but with a reasonable suspicion, may be screened before surgery. We recommend the Barbour et al.[1] questionnaire, which consists of several clinical questions and only two simple laboratory parameters, such as the erythrocyte sedimentation rate (ESR) and rheumatoid factor (►**Table 2**).[1] A score of 3 or more is 97% sensitive for rheumatological conditions, warranting a specialized referral.

Since the coexistence of osteomalacia and acetabular protrusion has been abundantly reported it is highly recommended to assess vitamin D levels in surgical patients. Several groups suggest studying vitamin D levels prior to a total joint replacement in all patients.[2,3]

The usefulness of the screening for tuberculosis or other pathogens during surgery is not clear. Other causes are very rare. We do not suggest any other preoperative studies for this reason. Idiopathic acetabular protrusion is diagnosed in patients presenting no causal factors. Although this is a diagnosis of exclusion, it is the most frequent form of presentation.

2. If the patient has a rheumatological diagnosis as the cause of the acetabular protrusion, how should timing of the surgery be managed?

When acetabular protrusion is secondary to a rheumatological condition, it is critical to work with the rheumatologist. If the rheumatological treatment has been abandoned, we recommend deferring the surgery and obtaining a formal evaluation.

Table 2 Inflammatory joint disease questionnaire by Barbour et al.[1]

Morning stiffness for more than 1 hour
Characteristic distribution of an inflammatory joint disease
First-degree relative with inflammatory joint disease
Clinical evidence of synovitis
Erythrocyte sedimentation rate $\geq$ 20 in males or $\geq$ 30 in females
Positive rheumatoid factor ($\geq$ 1/80)
Erosions on feet or hand radiographs
Improvement with non-steroidal anti-inflammatory drugs or corticosteroids

Note: For a score of 3 or more points, this questionnaire has 97% of sensitivity, 55% of specificity, a positive predictive value of 49%, and a negative predictive value of 97%.

Patients with rheumatological conditions have more complications from joint replacement surgery.[4,5] Therefore, optimization of their comorbidities (anemia, malnutrition etc.), as well as correct management with immunosuppressive drugs, is key to preventing perioperative complications.

The joint guidelines from the American Association of Hip and Knee Surgeons and the American College of Rheumatology[6] are probably the most important document regarding perioperative management of immunosuppressive treatment. Even though each patient requires an individualized assessment and treatment by the rheumatologist, international guidelines can be summarized as follows:

I. Assess inflammatory disease activity:

Ideally, the patient should be in remission or oligosymptomatic under an established treatment regimen. However, it is noteworthy that rheumatological patients undergoing arthroplasty reported that the risk of infection was more

Table 1 Causes of secondary acetabular protrusion

Infectious causes *Neisseria gonorrhoeae*, *Echinococcus* spp., *Staphylococcus* spp., *Streptococcus* spp., *Mycobacterium tuberculosis*
Neoplastic causes Hemangioma, metastasis (breast, prostate cancer), neurofibromatosis, radiation-induced osteonecrosis
Inflammatory causes Rheumatoid arthritis, ankylosing spondylitis, juvenile rheumatoid arthritis, psoriatic arthritis, acute idiopathic chondrolysis, Reiter syndrome, osteolysis secondary to arthroplasty
Metabolic causes Paget disease, osteogenesis imperfecta, ochronosis, acrodysostosis, osteomalacia, hyperparathyroidism
Traumatic causes Acetabulum fracture sequela, iatrogenic acetabular protrusion due to arthroplasty
Genetic causes Trichorhinophalangeal syndrome, trisomy 18, Sticker syndrome, Ehler-Danlos syndrome, Marfan syndrome, sickle-cell disease

relevant to them than disease flare-ups, which are manageable with drugs. It can be inferred that most patients would agree to modify their therapeutic scheme if it reduces the risk of infection, even if it results in symptoms reactivation.[7] Furthermore, the cardiovascular risk of these patients should be assessed since it can higher than most patients.[8]

II. Modification of immunomodulatory drugs:

a. Glucocorticoids:

The response to glucocorticoids is dose-dependent, and doses of prednisone higher than 15 mg per day are associated with an increased risk of complications. As such, patients requiring high doses must be considered as having an uncontrolled disease and surgery must be delayed until the disease is manageable with lower doses of corticosteroids.

Doses of prednisone (or an equivalent drug) of up to 15 mg, ideally lower than 10 mg, are considered safe, with no need for treatment interruption during the perioperative period.

The use of "stress doses" in the perioperative period is associated with a greater risk of infection and no "hemodynamic" benefit compared to not using them. Therefore, the use of corticosteroid stress doses during the perioperative period is not currently recommended.[9]

b. Disease-modifying antirheumatic drugs (DMARDs; including methotrexate, leflunomide, hydroxychloroquine, and sulfasalazine):

Several meta-analyses, including small randomized studies,[10,11] have not shown an increased risk of infection with continued administration of DMARDs during the perioperative period. However, stopping them may increase the risk of inflammatory flare-ups. Therefore, they normally must remain unchanged during the perioperative period.

c. Biological agents:

These agents are related to an increased risk of surgical site and overall infections. Thus, guidelines suggest scheduling the surgery at the end of the dosing cycle of each drug. For infliximab, for instance, which is administered every four weeks, the fourth-week dose must be omitted and the surgery should be scheduled at the fifth week, so the immunosuppressive effect is at its lowest point.

Therapy must be resumed at least two weeks after surgery, as long as the wound is well healed, has no signs of infection and no sutures remaining.

d. Anti-lupus medications (mycophenolate, cyclosporine, azathioprine, tacrolimus):

These are powerful immunosuppressive medications, and their use is conditioned by the severity of the clinical presentation. For mild cases, these agents must be stopped at least one week before surgery and resumed five to seven days after the procedure as long as there are no wound-related complications. In case of systemic compromise, the risk of medical complications from treatment termination overcomes the risk of infection, so therapy must be maintained. However, in a patient with a severe, active condition, the decision to perform an elective surgery must be discussed with the rheumatologist, and the procedure must be deferred whenever possible.

3. Preoperative planning: how do we classify protrusio? how do we plan component position?

Preoperative planning is essential to anticipate potential technical difficulties, to select implants, and to have intraoperative feedback. The technical aspects of planning have been discussed thoroughly.[12,13] Patients with acetabular protrusion present characteristic anatomopathological changes that must be considered during planning.

I. Medial or superomedial migration of the femoral head

Acetabular protrusion classifications are descriptive and have no therapeutic value. The key process is the COR restoration, which can be achieved using several methods. The best-known method was described by Ranawat et al.,[14] in which 20% of the pelvic height (PH) is calculated to build a rectangular isosceles triangle, with identical sides projected 5 mm lateral from the Köhler teardrop, proximal and then laterally from that point. The native COR is established at the center of the hypotenuse (►**Figure 1**). Several authors have questioned the accuracy of this method, stating that it results in a proximal and medial location.[15,16] More recently, different formulas have been published that estimate the COR based on the teardrop location with less deviation than previous methods:[17]

- Males: PH × 0.16 lateral / PH × 0.07 proximal;
- Females: PH × 0.155 lateral / PH × 0.065 proximal.

Our recommendation is to position the cup in an anatomic position during planning, ideally with the pole of the hemisphere touching the ilioischial line. The acetabular cavity secondary to the protrusion defect can be filled with a bone graft.

The appropriate cup size can be predicted with a different planning strategies. We have had a good experience with digital planning softwares, but their use may come with

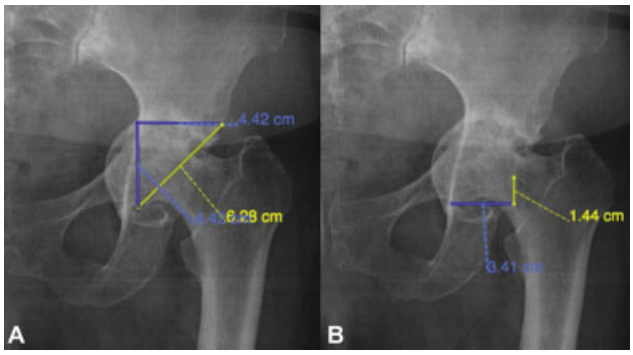

Fig. 1 Acetabular protrusion in an 83-year-old woman. Pelvic height: 21.92 cm. (**A**) Location of the hip rotation center according to the Ranawat method and (**B**) according to the method published by Fujii et al.[17] Note the most medial and proximal location obtained with method A.

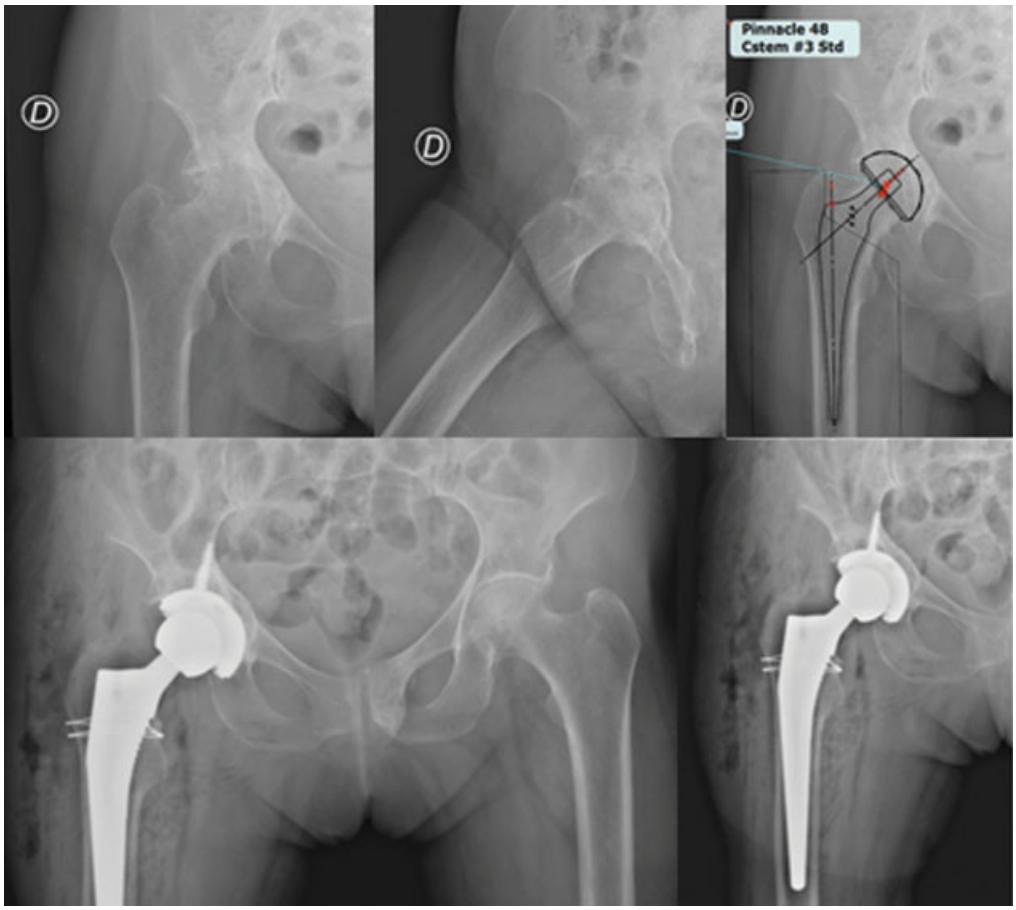

Fig. 2 Preoperative planning for a patient with acetabular protrusion. Postoperative radiograph with deformity correction as planned.

significant assocciated costs (►**Figure 2**). It is also possible to use an acetate template on the computer screen, which is our current method of choice.[18] If the digital radiograph has no markers, the three-point method is also feasible.[19]

II. Limb shortening, offset loss and soft tissue tension:

Due to the superolateral migration of the femoral head, usually patients present with a shortened limb and a decreased global offset of the hip. Correct COR restoration results in a lower and lateral position recovering tension from the abductor apparatus and increasing limb length. Another important point is the frequent presence of coxa vara, which must be considered during planning because most femoral stems have a comparatively greater cervical diaphyseal angle (CDA), which may contribute with leg length discrepancy. During planning, it is also crucial to recognize the presence of an excessive medial prominence (overhang) of the greater trochanter, also known as lateroversion of the greater trochanter,[20,21] which is very frequent in coxa vara patients.

Considering all the aforementioned aspects, preoperative planning can be used to obtain intraoperative feedback, recognize potential errors, and correct them, including the following:

- *Acetabular reamers larger than planned*: they suggest exaggerated medialization, with a cavity that can be bigger than the rim or an excessive growth that compromises the integrity of the acetabular walls.
- *Femoral broaching significantly smaller than planned:* this suggest an entry and broaching in varus, with premature contact between the broach tip and the lateral cortex. Sagittal plane malalignment must also be considered.
- *Use of a lateralized trial neck and/or trial heads of more than 5 mm than planned to achieve soft tissue tension, stability, and range of motion (ROM) with no impingement:* it may suggest inadvertent cup medialization with loss of acetabular offset.

Intraoperative fluoroscopy should be considered in the event of a deviation from the preoperative plan.

4. Technical details to consider during the approach, with emphasis on the posterior approach.

Regardless of the approach, femoral mobilization is limited by the medial migration of the femoral head and joint stiffness. In addition, the usual anatomical landmarks can be distorted.

Using a posterior approach, an incision is made at the center of the greater trochanter, approximately 3 cm proximal to the trochanter to 6 cm to 8 cm distal to the border of the vastus muscle. As a rule, the attachment of the gluteus maximus to the femur (up to 1.5 cm) is released and followed by an evaluation of the branches from the first perforating

artery.[22] Once identified, the piriformis tendon can be sutured, similarly to the rotators, and separated from the capsule. The capsule is also released and incorporated with one or two sutures; however, a substantial hip offset change is highly probable at the end of procedure, preventing the reattachment of these structures through transosseous sutures or, into soft tissues. The reflected head of the rectus and the capsule may also be released anteriorly for better visualization.

With direct visualization of the femoral neck and the posterior acetabular wall, we can see a calcified labrum in most cases. Using a curved osteotome, we remove around 5 mm of the posterior and superior acetabular rims, assuming these are remnants from a calcified labrum. The hip is mobilized to provide adequate visualization and to evaluate the possibility of safe dislocation, avoiding a fracture to the posterior acetabular wall. This procedure may be aided by a bone hook. If the dislocation is considered a high-risk procedure, we perform an osteotomy in situ, either with a single or double section ("napkin ring"). We often use a narrow saw blade in cases of protrusion. A reciprocating saw can be also be used. After the osteotomy, we usually review the femoral cut and decide whether to recut it or not. A long neck can significantly complicate acetabular visualization in these cases. The head is extracted ideally with a corkscrew. Osteotomes should not be used, and attempts to fragment the head remnant within the acetabulum can result in a fracture of the thin acetabular background.

Other potentially useful techniques during the approach are the Trousdale[23] triplanar trochanteric osteotomy or the modified Iyer[24,25] posterior approach.

5. Acetabulum preparation

The size of the acetabular component is estimated during preoperative planning, but also intraoperatively with reamers attached to a Kocher forceps in an attempt to determine the diameter of the acetabulum at the rim level before reaming. To avoid excessive (or unobserved) medialization, we recommend starting the acetabular preparation with a reamer no more than 4 mm smaller than the rim diameter, aiming to ream until achieving proper peripheral fit. Smaller reamers or curettes can be used carefully to prepare the acetabular floor to create only a bleeding bed, not to enlarge the cavity.

Due to the medial defect at the acetabular floor and the formation of cavity with an hourglass-like appearance, in which the acetabular rim works as the center of the hourglass and then the cavity expands, it is possible to mistakenly exaggerate medialization and growth during reaming resulting in thinning of the acetabular walls. This is why reaming must be anatomical, seeking an equatorial press-fit fixation avoiding the process described as "reaming-related medialization", so that the acetabular offset is not compromised.[26] Lateralization of the COR should also be avoided, since it increases joint reaction forces, liner wear and revision rates.[27] Elevation of the COR is less frequent, although it can occur in cases with superomedial defects.

Previous studies describe several techniques to achieve an adequate press-fit when using cementless cups, from a 2-mm underreaming to 1-mm line-to-line reaming.[28–30] In our experience, we perform 1 mm of underreaming with a completely hemispherical, non-elliptical cup, a technique validated for the implant we use.[30–32] In our case, the trial component is considered essential to ensure that the amount of graft to be placed at the floor is adequate. Cup abduction and anteversion are assured with the Meftah-Ranawat technique.[33]

6. Selecting a cementless, cemented, or porous metal cup: what does the literature say?

Historically, cemented cups have had significant success in patients with acetabular protrusions, so they are certainly a great option in trained hands.[34–37] Cementless cups, which are more frequently used in Chile, are also effective.[29–31] The most relevant series was published by the Mayo Clinic group.[38] They demonstrated an 85% of survival for cementless cups. It is noteworthy that 40% of these cups were positioned with no screws, relying solely on the press-fit achieved during surgery. The most used cups in this series included Pinnacle (DePuy, Raynham, MA, US) and Trilogy (Zimmer Biomet, Warsaw, IN, US), which are available in Chile.

Trabecular metal cups have theoretical advantages in complex primary cases. A recent study[39] from China demonstrated a 100% survival rate at 4.5 years using trabecular metal cups in patients with acetabular protrusion and rheumatoid arthritis. However, a study[40] based on the Swedish and Australian registries adds a note of caution about a particular model, Trabecular Metal (ZimmerBiomet), due to its higher revision rate compared with other cementless cups. Although they seem to be reasonable option, its cost may be a limitation.

7. What bone graft alternative should be used? How should we prepare it?

Acetabular bone grafting has been used in patients with acetabular protrusion since the 1980s. Heywood[41] used a solid graft in 9 patients, with 100% integration and good clinical evolution. Crowninshield et al.[42] proposed that acetabular COR restoration reduces the stress on the medial wall and the risk of failure. Subsequently, Ranawat and Zahn[21] gave greater support to the concept of COR restoration, using medial bone grafting. In 23 patients (27 hips), using bone graft, they lateralized the acetabular component with COR normalization and supplementation of the medial wall. In the same study,[21] they formulated recommendations regarding bone graft use: when the protrusion is less than 5 mm and the medial wall is reasonably strong, grafts are not necessary when it is more than 5 mm and the medial wall is thin but intact, a graft should be used. In cases with overt medial wall failure, they recommended grafting with additional supplementation methods.[21]

Autografts, allografts, or bone substitutes are options available to the surgeon. Femoral head autograft is the most widely used alternative due to its availability. Solid autografts have been proposed in different ways with good outcomes;[21,41] however, morcellized autografts are often selected due to their reproducibility, high rates of graft consolidation, and dense bone formation[43] (►**Figure 3**).

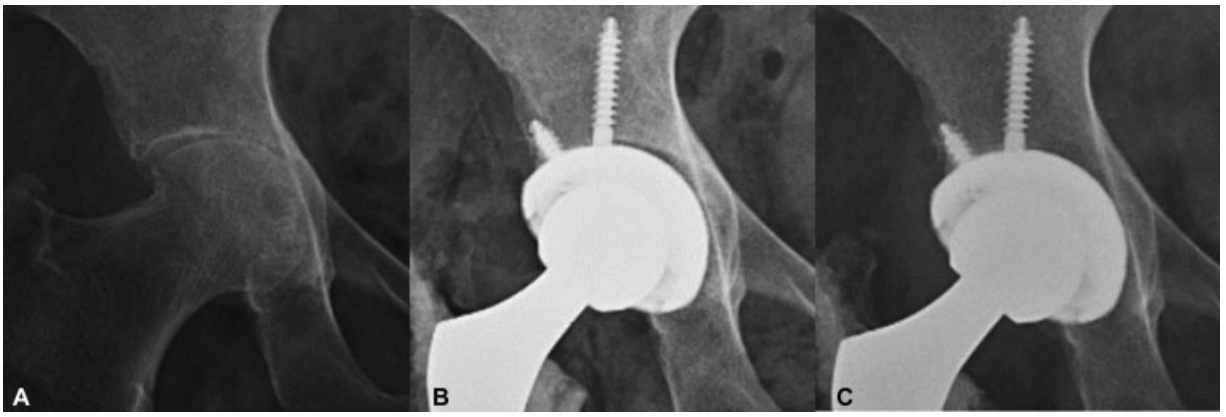

Fig. 3 (**A**) Preoperative image of a patient with an acetabular protrusion. (**B**) Immediate postoperative radiograph revealing restoration of the hip rotation center and a graft at the acetabular floor. (**C**) Radiograph three months later, showing graft incorporation and dense bone formation.

Our technique is to obtain it directly from the femoral head using 38-mm reamers.

The outcomes from grafts with cemented and cementless implants are excellent at the short, medium and long terms. Using cemented cups, survival at 12 years ranged from 90% to 94%, and, at 20 to 28 years, the survival rate was 73%.[44–46] Mullaji and Shetty,[30] using 8-mm to 10-mm morcellized bone graft with cementless cups, reported 90% of good to excellent outcomes at 4.2 years, with 100% graft incorporation. Baghdadi et al.[38] reported a 83% acetabular survival rate at 15 years using a cementless cup and morcellized graft.

The addition of vancomycin powder (1 g mixed with the graft) may be a reasonable evidence-based practice that is not directly related to protrusion reconstructions.[47] Our group has used it in cases with a higher risk of infectious complications.

Once graft preparation is finalized, we position it with a specially-designed forceps and compact it in situ with a polyethylene impact ball. With the impacted graft, we evaluate if the amount is enough by positioning the last reamer used during cup preparation.

8. How do we select a femoral stem? What are the anatomical landmarks are important for femoral reconstruction in patients with acetabular protrusion?

The femoral stem is usually selected based on three variables:

I. Bone quality: since these patients are usually chronic corticosteroid users, with an average age ranging from 65 to 70 years, and are predominantly female,[14] cemented stems may be preferred. Proximal femoral morphology should be noted (Dorr et al.[48] classification: A, B or C), along with objective measurements, such as the "calcar-to-canal ratio" or the "cortical thickness index," as described by Dorr et al.[48]

II. CDA: in patients with coxa vara, stems with a decreased CDA may be preferred to accurately recreate the length and offset of the extremity although most current stem designs present CDAs greater than 125°.
Normally, when the COR is moved laterally and distally to place the cup back in its correct position, the global offset and the tension of the abductor apparatus are increased. Therefore, the loss of femoral offset with currently available stems is compensated, and stems with extended or lateral offset are often not required.

III. Overhang of the greater trochanter: the greater trochanter tends to medially displace the entry of the initial broaches, which can lead to varus broaching. At the same time, trying to avoid the usually posterolateral prominence can lead to an anterior entry and sagittal plane (recurvatum) deviation.
Cemented stems have a lower tolerance to varus compared to cementless stems,[49,50] due to the generation of a thinner cement mantle at the calcar level, resulting in a higher risk of fracture and loosening.
Data is not categorical about which type of stem is superior in patients with acetabular protrusions. However, when information from studies comparing cemented and cementless stems in patients with rheumatoid arthritis is extrapolated, there are no differences between them.[51]

Strategies to deal with these anatomical challenges include the following:

- Low femoral neck osteotomy, following preoperative planning, to avoid limb lengthening and using femoral stems with CDA in varus ($< 125°$).
- Position the initial box osteotome lateralized enough, even through the greater trochanter.
- Broach pushing the broach to posterior and lateral.
- Use a curette or curved rasp to lateralize the canal at the level of the greater trochanter. Some systems include trochanteric cylindrical reamers for these purposes.
- Use femoral stem designs with a reduced superolateral shoulder.

9. Postoperative management: immediate full weight-bearing? Which postoperative clinical and radiological follow-ups are important?

Intraoperative results determine weightbearing status and when to start rehabilitation. Weightbearing status has been determined differently in several studies using morselized bone graft and a satisfactory fixation of an uncemented cup. Some series[29,39] have deferred weightbearing for the first days or weeks, while other have used partial or full weightbearing. However, there is no evidence that any of these strategies interfere with graft integration. Even more, Rosenberg et al.[46] prescribed bed rest for six weeks and then partial weightbearing for three months, also with good outcomes. Our recommendation is to allow weightbearing as tolerated with technical aids, if required, provided that the intraoperative fixation and the postoperative radiograph are satisfactory.

The frequency of radiographic follow-up is debatable. Zhen et al.[39] recommended radiographs in the immediate postoperative period and then at six weeks, three months, six months, and then once a year. Zuh et al.[29] recommended clinical and radiographic follow-up at three months and then annually. Both series report good outcomes. In addition, studies[29,40] show different graft integration times, ranging from 4.5 months to 1 year. Therefore, follow ups during the first year may be useful, to demonstrate, among other aspects, the integration of the graft.

We perform radiographic and clinical follow-up evaluations at the immediate postoperative period, at six weeks, six months (when the graft should be integrated), one year, and then, annually. In addition, we perform a clinical check-up three weeks after surgery.

10. Should I expect the same implant survival time as in other patients?

Although implant survival depends on multiple factors, the main modifiable factor in patients with acetabular protrusion is the adequate lateromedial restoration of the COR. In 162 patients with acetabular protrusion, Baghdadi et al.[27] showed that for every 1 mm of medial or lateral displacement of the native COR the risk of revision increased by 24%, with a survival rate for aseptic revision of 89% and 85% for cemented and cementless acetabular components respectively.

Zuh et al.[29] used a morcellized graft and a cementless acetabular component in 39 hips with acetabular protrusion; they had no revisions at 4.5-years follow-up with a graft integration rate of 100%. Rosenberg et al.[46] also used a morcellized graft in 36 total arthroplasties in patients with rheumatoid arthritis and acetabular protrusion, with an implant survival of 90% at an average follow-up of 12 years. In 65 patients, Baghdadi et al.[38] used morcellized grafts for the acetabular floor and a cementless acetabular component in 89% of the subjects, which had a 15-year, revision-free survival rate of 70% in general, 83% for the femoral component and 85.4% for the acetabular component. When comparing this survival rate to the survival free from any reoperation of 96% among subjects with the current cementless friction pairs, it is plausible to suggest that the survival of protrusion implants is lower. However, most of these studies did not use the latest polyethylenes, which may affect these results.[52]

Conclusion

The management of total hip arthroplasty in patients with acetabular protrusion requires a multidimensional approach considering the pre-, intra-, and postoperative periods. A systematic approach, along with the thorough knowledge and experience of the surgical team, are required to offer the patient the best chance of success.

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