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Total hip arthroplasty in the treatment of developmental dysplasia of the hip

Gelişimsel kalça displazisinde total kalça protezi

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Total kalça artroplastisi (TKA) gelişimsel kalça çıkığı ve - ya displazisine bağlı olarak gelişen kalça osteoartritinin seçkin tedavi yöntemidir. Ancak, kalça çıkığı veya displazisi çeşitli derecelerde kemik ve yumuşak doku sorunları nedeniyle TKA'yı teknik olarak zorlaştırır. Diğer taraftan, bu hastalar genellikle gençtir ve protezin dayanıklılığı önemli bir sorundur. Bu hastalarda kemik yapısı ve stoğunun uygunluğuna göre çimentolu veya çimentosuz komponentler kullanılabilir. Hastalar genellikle genç oldukla - rından çimentosuz komponentler daha çok tercih edilir. Asetabuler komponenti kemik stoğu izin verdiğince anatomik yerine yerleştirmek TKA'nın uzun dayanımı ve daha iyi fonksiyonel sonuçlar için önemlidir. Asetabuler komponentte yeterli stabiliteyi sağlamak için yapısal greft uygulaması, kontrollü medial duvar perforasyonu (medializasyon) veya asetabuler komponenti hafif yükseğe yerleştirme (high hip center) yöntemleri kullanılabilir. Femoral tarafta anatomi izin verirse kısaltmasız olarak veya gereğinde kısaltma yöntemleri kullanılarak femoral komponent uygulanabilir. Bu yazıda kalça displazisinin asetabuler ve femoral deformite sınıflamasına göre rekonstrüksiyon seçenekleri tartışılmaktadır.

Total hip arthroplasty (THA) is the preferred treatment for patients with severe arthritis of the hip secondary to developmental hip dislocation or dysplasia. However, THA may be difficult due to bone and soft tissue problems that arise from hip dislocation or dysplasia. Another problem is that patients are usually young, which may affect the long-term survival of the prosthesis. Either cemented or uncemented components can be used depending on bone structure and bone stock. Uncemented components are more preferable because of the young age of the patients. From a biomechanical standpoint, the placement of the acetabular component in its true anatomical location is the main goal for survival and better functional results of THA. To ascertain the stability of the acetabular component, superior grafting, controlled medial wall perforation (medialization), or giving the position of a high hip center may be used. On the femoral side, various femoral components may be used with or without a shortening osteotomy. In this article, reconstruction options for developmental hip dysplasia are discussed depending on acetabular and femoral features of the deformity.

Coxathrosis secondary to the untreated developmental dysplasia of the hip (DDH) is still encountered against all the screening and early treatment methods of DDH. In mildly deformed hips, total hip arthroplasty (THA) can be performed using standard techniques. Severely dysplastic hips present challenging surgical problems. Even Charnley stated that "in severe dysplastic hips, THA is an operation that will predispose the patient to unnecessary risks". The primary problems with these patients are the bony deformities, soft tissue contractures and the relatively young age and higher activity level of these individuals. In this review, we summarize the DDH classifications, acetabular and femoral implant options depending on these classifications and discuss the contamporary surgical techniques of THA in the treatment of coxarthrosis secondary to DDH.

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Anatomy and classification

Thorough understanding of the bony and soft tissue deformities induced by dysplasia is crucial for the success of the THA. Primary deformities may be further accentuated by secondary ones produced by previous surgeries. Deformities are closely correlated by the severity of the dysplasia.[2] The acetabulum is shallow and oval.[3] As the severity of the dysplasia increases, the acetabular anteversion is increased and anterosuperior bone stock decreased. In high dislocations, the hemipelvis and the acetabular fossa may be underdeveloped and rotated.

On the femoral side, the femoral head may be normally developed in less severe cases, the neck is usually in valgus;[4] with increasing severity, the head gets smaller and the neck shorter and more anteverted.[4,5] The trochanter is located posteriorly; the medullary canal is straight and narrow (Figure 1).[6]

Secondary soft tissue deformities follow the primary bony deformities: the hamstrings, adductors, quadriceps and iliopsoas are short.[7] The acetabular capsule thickens and migrates proximally with the dislocated head of the femur. Iliopsoas tendon is usually hypertrophic and may cross the capsule. Sciatic nerve shortens and may be damaged trying to bring the hip center to its anatomical level.[8] Anterior to the acetabulum, the femoral nerve may be migrated laterally and may be injured by the placement of inadvertent retractor placement or lengthening. Long standing leg length discrepancy may cause pelvic tilt, increased lumbar lordosis and genu valgum.

Classifications are useful tools to delineate treatment algorithms and to follow up the success of these treatments. The most popular classification for adult hip dysplasia is the Crowe classification,[5] followed by Efthekar and Hartofilakidis classifications.[9]

Crowe classification uses the proximal femoral head displacement from the line connecting the distal borders of teardrops and has 4 types. Type 1 hips has less than 50% of proximal migration of the measured femoral head, type 2 has 50-75 %, type 3 75-100 % and type 4 dysplastic hips has more than 100% proximal migration. (Figure 2).

Hartofilakidis classification has three types: dysplasia, low (subtotal) dislocation and high (total) dislocation (Figure3 a,b).[9] Dysplasia refers to subluxated femoral heads still in the true acetabulum; low dislocation refers to the dislocated femoral heads articulating with secondary acetabulum, usually with anterior and posterior wall deficiencies and high dislocation refers to high riding femoral heads floating posterosuperiorly in relation to the small and undevelopped acetabular fossa.

Acetabular reconstruction options

The succes in the acetabular reconstruction in DDH patients is balancing the stability of the component and the biomechanical advantage of bringing the acetabular center of rotation to its anatomical level. In the following part, Crowe classification will be used as reference for the acetabular reconstruction options.

Crowe type 1

In Crowe type 1 dysplastic hips, the acetabulum is normal or ovoid in the vertical plane. The bone quality is good and standard acetabular cups – with or without screw augmentation – may be used.

Crowe type 2 and 3

In Crowe type 2-3 dysplastic hips, the femoral head is migrated on the acetabular-iliac corner. This configuration which brings a superior acetabular defect also causes various degrees of anterior and posterior deficiencies. Crowe type 2-3 dysplastic hips are the most discussed and difficult acatabular reconstructions. Various surgical techniques are listed to secure the acetabular component stability. The coverage and stability of the acetabular component

Figure 1. AP radiograph of a bilateral high dislocation

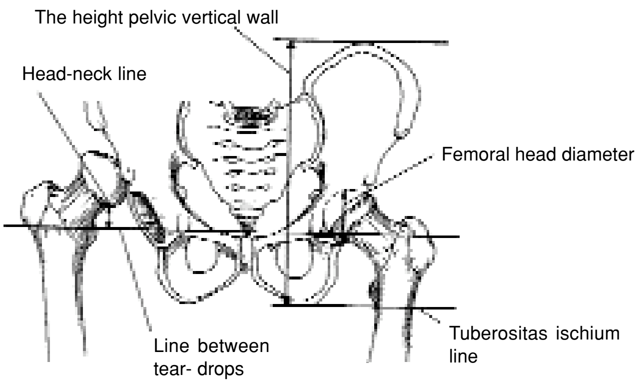


Figure 2. Crowe classification

can be obtained by reaming up to the medial wall. The main problem with medializing the acatabular component is impingement of ischion to the posteriorly located greater trochanter or the neck of the femoral component causing anterior dislocation.[6] Resection of the impinging part of the ischion, extended offset femoral components or lateralized liners may be used to prevent this complication.[3,10] There is no concensus regarding how much of the acetabular component can overhang posterolaterally. Within adequate anteversion and inclinaton degrees, 25% overhang is accepted biomechanically non deleterious. The superolateral defect may be grafted with cancellous acetabular reamings or using cancelous chips from the femoral head. In severe dysplasia the following techniques may be used:

- Superolateral structural grafting

- Controlled perforation of the medial acetabular wall (acetabuloplasty, cotyloplasty)

- High hip center

Structural acetabular grafting

Structural acetabular grafting is a bone stock increasing procedure. After placing the acetabular component in its anatomical level, grafting the posterosuperior gap with the femoral head has advantages such as ease of union and cost. Although structural acetabular grafting brings the center of rotation of the hip to its anatomical and biomechanically favourable place,[11] it is technically difficult and increase the surgical time. There is also the risk of early or medium term failure if the fixation of the graft is not adequate or graft resoption occurs.

Cemented or cementless components can be used with structural grafting. The results of cemented fixation is variable and less used. Gerber and Harris reported 21% and 46% failure rate in a series of 47 patients at 7 [13] and 10 [12] year follow up, respectively. Numair et al [14] reported 12% acetabular revision at average 10 year follow up, in a series of 190 patients (230 hips) that received cemented Charnley THA. In their series of 39 THA with structural graft and cementless acetabular components, Hintermann and Morscher [15] reported 100% graft union at 7.6 years. 22 grafts showed various degrees of resorbtion, two acetabular compoents were loose and only one acetabular revision was needed. Saglam et al [6] reported in their series of 42 Crowe type 3-4 dysplastic hips, 17 THA necessitated structural grafting and cementless acetabular component and all the grafts were successfully united and the THAs were doing well at 55 months follow up.

Controlled perforation of the medial wall

This technique is the intentional reaming of the medial wall of the acetabulum and the medialisation of the acetabular component. [9,16-18] Medialisation of the acetabular component decreases the joint reaction forces and helps the coverage of the component. The primary disadvantage is decreased medial wall support to the component and possible medial migration risk of the component before bone

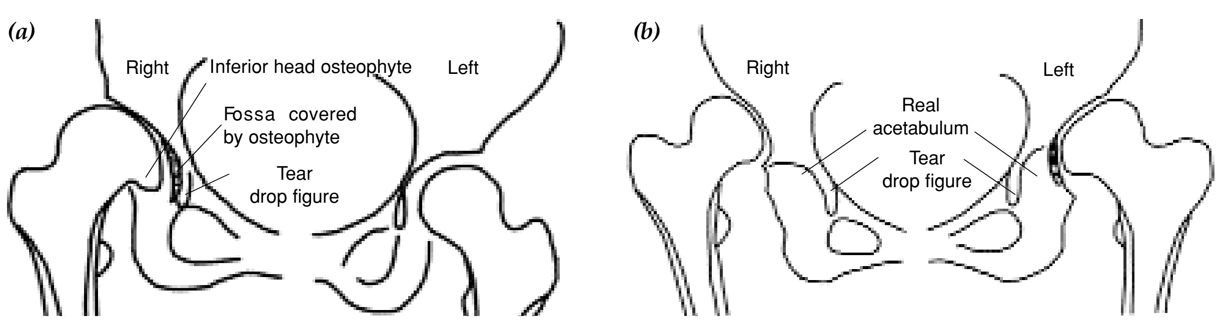


Figure 3. Hartofilakidis classification. (a) Normal and dysplastic hips. (b) Low and high dislocations

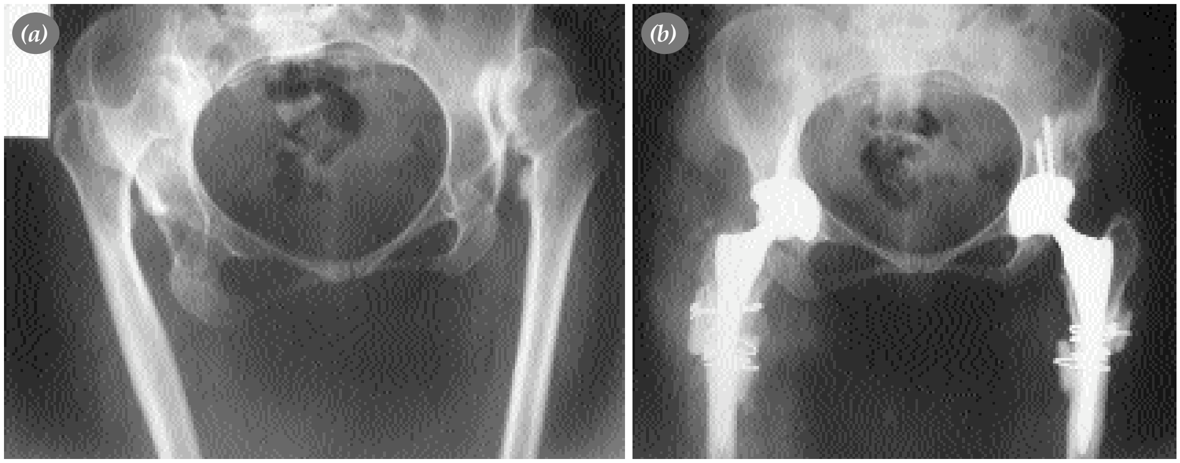


Figure 4. Anatomical placement of acetabular cementless cups. **(a)** Preoperative **(b)** Postoperative

ingrowth. Hartofilakidis [9] reported 100% acetabular survival at 5 years and 93% at 10 years follow up in 86 THA of 66 patients. Dorr et al followed 24 THA of 19 patients for an average of 7 years and reported no failures; they concluded that controlled perforation of the medial wall is a safe and reproducible technique.

High hip center

High hip center defines the proximal placement of the acetabular component from its anatomical level. This technique is mostly used to have better coverage of the acetabular component without grafting or to avoid the need of femoral shortening. The most important disadvantage is the biomechanical. Computed tomography load models [19, 20] revealed that loads across the hip joint are significantly higher with superolateral reconstructions; but if the medialisation is adequate, even with superior acetabular center of rotation, loads may be decreased. [21] Impingement in flexion and/or extension may also be a problem and should be checked with trial components.

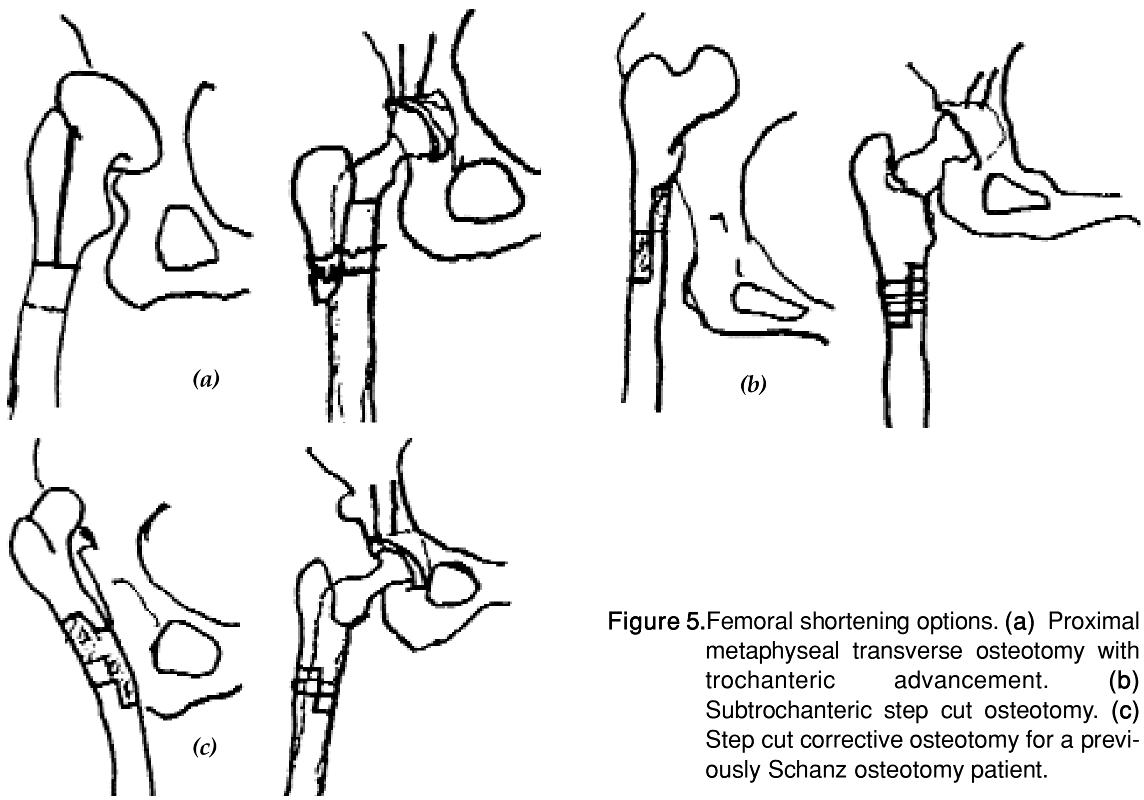


Figure 5. Femoral shortening options. **(a)** Proximal metaphyseal transverse osteotomy with trochanteric advancement. **(b)** Subtrochanteric step cut osteotomy. **(c)** Step cut corrective osteotomy for a previously Schanz osteotomy patient.

Russotti and Harris [22] reported 16% revision rate on 37 high hip center THA at 11 years and underlined that when using high hip center technique, the component should not be lateralized. Pagnano et al [23] reported that acetabular components placed 15 mm proximal than the anatomical level – even though not lateralized – necessitated significantly higher rates of acetabular and femoral revisions.

Crowe type IV

The acetabulum is usually very small in this type of severe dysplasia that the femoral head is situated very high. Anatomical acetabular reconstruction can be performed using very small sizes of acetabular reamers. The bone stock is situated posteriorly and very soft in these acetabula. Some bone preservation can be attempted using the last planned reamer in reverse mode, impacting rather than removing bone from the acetabulum. [10] Small acetabular cups necessitates 22 mm heads in order to achieve adequate polyethylene thickness. If possible, the acetabulum should be reamed to accept an acetabular component with ceramic liner (Figure 4a,b).

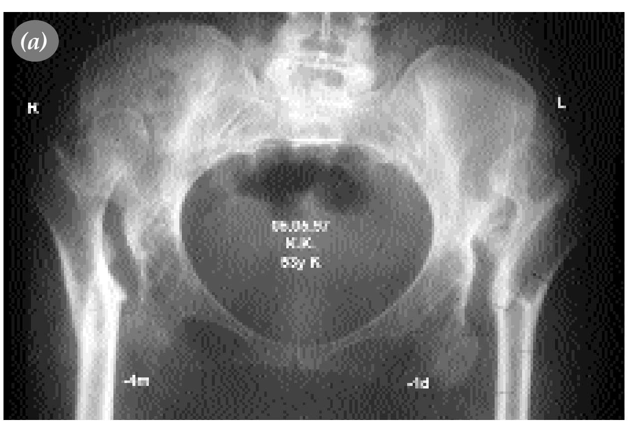
Femoral reconstruction options

The dysplastic femur has a narrow and straight medullar canal, increased anteversion and the neck is valgus. The trochanter is located posteriorly. The femoral reconstruction should be planned in relation to the severity of the femoral deformity and the level of the acetabular component. The main problem with anatomical acetabular reconstruction is the reduction of the hip. If this problem is anticipated femoral shortening should be planned in order not to overstretch the neurovascular structures and to correct preoperative bony deformities. Many shortening techniques were described; some surgeons prefer shortening from the greater trochanter level but proximal metaphyseal shortening osteotomies are the most widely used.[24-26]

Proximal metaphyseal shortening osteotomy can be performed transverse,[27,28] oblique,[29] step-cut, [3,26] or chevron type.[30] Rotational stability of the osteotomy is mostly increased with the technical difficulty of the osteotomy, the most rotationally stable being step cut and chevron type osteotomies. [Figure 5a,b,c)

The osteotomy may be stabilized with cables using the shortening segments of bone as autografts around the osteotomy site.[3] Some authors reported that no extra fixation method was needed with a femoral component that stabilized the osteotomy as an intramedullary nail.[27,31] Paavilainen et al described the screw fixation method after trochanteric osteotomy and proximal shortening.[32]

Cemented ad cementless femoral stems may be used after subtrochanteric osteotomy. Rotational correction is easier with the cemented stems but there is always a risk that the cement infiltration to the osteotomy site and impeding bone healing. The use of cementless components is favored in these relatively young group of patients with the reason that the stem may be used to stabilize the osteotomy and has a promising longevity.



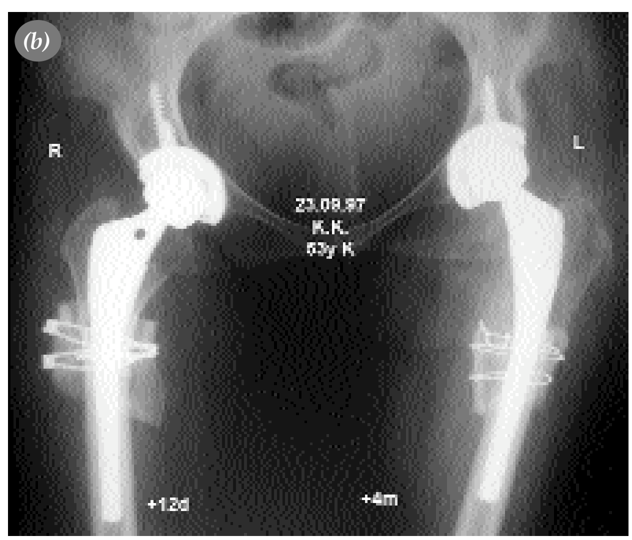


Figure 6. Bilateral high dislocated and osteotomized hips, proximal metaphyseal corrective shortening osteotomy with cementless implants. **(a)** Preoperative **(b)** Postoperative

The anatomical deformities and the need for an osteotomy are the main parameters that affect the choice femoral component. Primary components may be used in Crowe type 1 and 2 dysplastic hips.[6,27,33,34] Masonis et al reported 100% union rate, using the highly modular (S-Rom) femoral components.[31] Some others recommended the use of custom made components.[35]

We prefer proximal metaphyseal step cut shortening osteotomy and the use of the cut segment as an overlay autograft fixed with cables. We do not use custom components and up to now, we were able to achieve satisfactory results (solutions) with primary components (Figure 6a, b).

The complexity of THA in coxarthrosis secondary to DDH is highly related to the severity of the deformity. In lesser degree deformities, primary components and standard techniques may be used. Severe deformities usually necessitate special techniques and implants for acetabular and femoral reconstruction. Preoperative implant and surgical technique planning is also a very important step. If the ideal steps are planned and meticulously executed, THA for dysplastic and dislocated hips can be as successful as primary THA.

References

1. Charnley J, Feagin JA. Low-friction arthroplasty in congenital subluxation of the hip. Clin Orthop Relat Res 1973;(91):98-113.
2. Lee BP, Cabanela ME, Wallrichs SL, Ilstrup DM. Bone-graft augmentation for acetabular deficiencies in total hip arthroplasty. Results of long-term follow-up evaluation. J Arthroplasty 1997;12:503-10.
3. Sener N, Tozun IR, Asik M. Femoral shortening and cementless arthroplasty in high congenital dislocation of the hip. J Arthroplasty 2002;17:41-8.
4. Robertson DD, Essinger JR, Imura S, Kuroki Y, Sakamaki T, Shimizu T, et al. Femoral deformity in adults with developmental hip dysplasia. Clin Orthop Relat Res 1996;(327):196-206.
5. Crowe JF, Mani VJ, Ranawat CS. Total hip replacement in congenital dislocation and dysplasia of the hip. J Bone Joint Surg [Am] 1979;61:15-23.
6. Saglam N, Sener N, Beksac B, Tozun IR. Total hip arthroplasty and problems encountered in patients with high-riding developmental dysplasia of the hip. [Article in Turkish] Acta Orthop Traumatol Turc 2002;36:187-94.
7. Haddad FS, Masri BA, Garbuz DS, Duncan CP. Primary total replacement of the dysplastic hip. Instr Course Lect 2000;49:23-39.
8. Cameron HU, Eren OT, Solomon M. Nerve injury in the prosthetic management of the dysplastic hip. Orthopedics 1998;21:980-1.
9. Hartofilakidis G, Stamos K, Karachalios T, Ioannidis TT, Zacharakis N. Congenital hip disease in adults. Classification of acetabular deficiencies and operative treatment with acetabuloplasty combined with total hip arthroplasty. J Bone Joint Surg [Am] 1996;78:683-92.
10. Sanchez-Sotelo J, Berry DJ, Trousdale RT, Cabanela ME. Surgical treatment of developmental dysplasia of the hip in adults: II. Arthroplasty options. J Am Acad Orthop Surg 2002;10:334-44.
11. Silber DA, Engh CA. Cementless total hip arthroplasty with femoral head bone grafting for hip dysplasia. J Arthroplasty 1990;5:231-40.
12. Mulroy RD Jr, Harris WH. Failure of acetabular autogenous grafts in total hip arthroplasty. Increasing incidence: a follow-up note. J Bone Joint Surg [Am] 1990;72:1536-40.
13. Gerber SD, Harris WH. Femoral head autografting to augment acetabular deficiency in patients requiring total hip replacement. A minimum five-year and an average seven-year follow-up study. J Bone Joint Surg [Am] 1986;68:1241-8.
14. Numair J, Joshi AB, Murphy JC, Porter ML, Hardinge K. Total hip arthroplasty for congenital dysplasia or dislocation of the hip. Survivorship analysis and long-term results. J Bone Joint Surg [Am] 1997;79:1352-60.
15. Hintermann B, Morscher EW. Total hip replacement with solid autologous femoral head graft for hip dysplasia. Arch Orthop Trauma Surg 1995;114:137- 44.
16. Dorr LD, Tawakkol S, Moorthy M, Long W, Wan Z. Medial protrusio technique for placement of a porous-coated, hemispherical acetabular component without cement in a total hip arthroplasty in patients who have acetabular dysplasia. J Bone Joint Surg [Am] 1999;81:83-92.
17. Hartofilakidis G, Karachalios T. Total hip arthroplasty for congenital hip disease. J Bone Joint Surg [Am] 2004;86:242-50.
18. Hess WE, Umber JS. Total hip arthroplasty in chronically dislocated hips. Follow-up study on the protrusio socket technique. J Bone Joint Surg [Am] 1978;60:948-54.
19. Delp SL, Wixson RL, Komattu AV, Kocmond JH. How superior placement of the joint center in hip arthroplasty affects the abductor muscles. Clin Orthop Relat Res 1996;(328):137-46.
20. Delp SL, Maloney W. Effects of hip center location on the moment-generating capacity of the muscles. J Biomech 1993;26:485-99.
21. Doehring TC, Rubash HE, Shelley FJ, Schwendeman LJ, Donaldson TK, Navalgund YA. Effect of superior and superolateral relocations of the hip center on hip joint forces. An experimental and analytical analysis. J Arthroplasty 1996;11:693-703.
22. Russotti GM, Harris WH. Proximal placement of the acetabular component in total hip arthroplasty. A long-term follow-up study. J Bone Joint Surg [Am] 1991;73:587-92.
23. Pagnano W, Hanssen AD, Lewallen DG, Shaughnessy WJ. The effect of superior placement of the acetabular component on the rate of loosening after total hip arthroplasty. J Bone Joint Surg [Am] 1996;78:1004-14.
24. Papagelopoulos PJ, Trousdale RT, Lewallen DG. Total hip arthroplasty with femoral osteotomy for proximal femoral deformity. Clin Orthop Relat Res 1996;(332):151-62.
25. Hartofilakidis G, Stamos K, Karachalios T. Treatment of high dislocation of the hip in adults with total hip arthroplasty. Operative technique and long-term clinical results. J Bone Joint Surg [Am] 1998;80:510-7.
26. Paavilainen T, Hoikka V, Paavolainen P. Cementless total hip

arthroplasty for congenitally dislocated or dysplastic hips. Technique for replacement with a straight femoral component. Clin Orthop Relat Res 1993;(297):71-81.
27. Erdemli B, Yilmaz C, Atalar H, Guzel B, Cetin I. Total hip arthroplasty in developmental high dislocation of the hip. J Arthroplasty 2005;20:1021-8.
28. Yasgur DJ, Stuchin SA, Adler EM, DiCesare PE. Subtrochanteric femoral shortening osteotomy in total hip arthroplasty for high-riding developmental dislocation of the hip. J Arthroplasty 1997;12:880-8.
29. Anwar MM, Sugano N, Masuhara K, Kadowaki T, Takaoka K, Ono K. Total hip arthroplasty in the neglected congenital dislocation of the hip. A five- to 14-year follow-up study. Clin Orthop Relat Res 1993;(295):127-34.
30. Becker DA, Gustilo RB. Double-chevron subtrochanteric shortening derotational femoral osteotomy combined with total hip arthroplasty for the treatment of complete congenital dislocation of the hip in the adult. Preliminary report and description of a new surgical technique. J Arthroplasty 1995; 10:313-8.
31. Masonis JL, Patel JV, Miu A, Bourne RB, McCalden R, Macdonald SJ, et al. Subtrochanteric shortening and derotational osteotomy in primary total hip arthroplasty for patients with severe hip dysplasia: 5-year follow-up. J Arthroplasty 2003;18(3 Suppl 1):68-73.
32. Eskelinen A, Helenius I, Remes V, Ylinen P, Tallroth K, Paavilainen T. Cementless total hip arthroplasty in patients with high congenital hip dislocation. J Bone Joint Surg [Am] 2006;88:80-91.
33. Ozturkmen Y, Karli M, Dogrul C. Cemented total hip arthroplasty for severe dysplasia or congenital dislocation of the hip. [Article in Turkish] Acta Orthop Traumatol Turc 2002; 36:195-202
34. Tabak AY, Celebi L, Muratli HH, Yagmurlu MF, Aktekin CN, Bicimoglu A. Cementless total hip replacement in patients with high total dislocation: the results of femoral shortening by subtrochanteric segmental resection. [Article in Turkish] Acta Orthop Traumatol Turc 2003;37:277-83.
35. DiFazio F, Shon WY, Salvati EA, Wilson PD Jr. Long-term results of total hip arthroplasty with a cemented custom-designed swan-neck femoral component for congenital dislocation or severe dysplasia: a follow-up note. J Bone Joint Surg [Am] 2002;84:204-7.