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PŮVODNÍ PRÁCE

Acetabular Component Position of the Noncemented Total Hip Endoprosthesis after Previous Chiari Pelvic Osteotomy

Postavení acetabulární komponenty necementované totální endoprotézy kyčle po předchozí Chiariho osteotomii pánve

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ABSTRACT

INTRODUCTION

The aim of the study was to determine the validity of acetabular component position of the noncemented total hip endoprosthesis after Chiari pelvic osteotomy.

MATERIAL AND METHODS

The study involved 75 patients operated on at the Institute of Orthopedic Surgery „Banjica" in the period from 1990–2009. The first group consisted of 39 patients (46 hips) who underwent Chiari pelvic osteotomy and also later the implantation of a noncemented total hip endoprosthesis. A control group consisted of 36 patients (47 hips) who underwent total hip arthroplasty due to degenerative hip dysplasia.

RESULTS

In the previously operated patients the centre of rotation of the hip was on the average placed more proximally, while in the control group of patients the position of the acetabular component was closer to the anatomical one. In the group of patients after Chiari osteotomy the mean acetabular cup abduction angle rated 41.8° ± 9.8°, while in the control group this value was on the average higher (45.4° ± 8.6°).

DISCUSSION

There was a significant difference between the studied groups in relation to the distance between the acetabular component of endoprosthesis and the acetabular teardrop ($t = -2.763$; $p = 0.007$). No statistically significant difference was determined in the mean value of the angle of acetabular abduction component of endoprosthesis between the studied groups of patients ($t = 1.878$; $p = 0.064$).

CONCLUSIONS

Acetabular component position of the total hip endoprosthesis was not compromised by anatomic changes of the acetabulum caused by Chiari pelvic osteotomy.

Key words: Chiari pelvic osteotomy, acetabular component position, total hip arthroplasty.

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INTRODUCTION

The adequate acetabular component position can be a highly demanding procedure in cases of altered anatomic relationships that are to a lesser or higher degree present in patients with congenital hip dysplasia (3, 9).

During surgical procedure of total hip endoprosthesis implantation it is our goal to place the acetabular component into a bearing created at the site of the true acetabulum. If this position does not render sufficient implant coverage to provide its stability and longevity, the use of acetabular augmentation is recommended (18, 25, 26). Patients with congenital hip dysplasia may not have sufficient bone tissue at the site of the true acetabulum to provide a good support and coverage of the implant. In such cases one is forced to position the acetabular component at the site with sufficient bone tissue quantity, most often superiorly and laterally in relation to the position of the true acetabulum. Laterally and/or superiorly dislocated center of rotation of the hip increases the longitudinal loading of the acetabular component during activities, which accelerates insert wear and shortens endoprosthetic longevity (1, 26, 31).

It has been revealed that the acetabular component position of endoprosthesis can significantly influence the longitudinal loading that is transferred onto the insert thus thinning it with time (1). The recommended position of the acetabular component is from 30°–50° of abduction from the horizontal plane (21).

Femoral head medialization by Chiari pelvic osteotomy was a frequently used procedure in the second half of the 20th century. Chiari surgery is nowadays recommended in patients with insufficient femoral head coverage when a full reconstruction of anatomic correlations cannot be expected even by utilization of other more efficient and technically more challenging pelvic osteotomies (14, 19). It is desirable that the patient has good strength of abductor musculature, preserved hip joint mobility, as well as absence of advanced degenerative disorders. A technically precisely performed Chiari osteotomy can result in the patient's good clinical and radiographic outcome over the next postoperative 10–20 years (24). Despite improvement of joint congruency, degenerative disorders of the hip joint develop over time, so that the implantation of total hip endoprosthesis becomes inevitable (Figs 1 and 2).

The aim of the study was to determine the validity of acetabular component position of the noncemented total hip endoprosthesis after Chiari pelvic osteotomy, as well as the purposefulness of bone graft usage that could additionally improve this position.

MATERAL AND METHODS

The included 75 patients (97 hips) with implanted noncemented total hip endoprosthesis due to a diagnosed degenerative disease. Thirty-nine patients (52%), i.e. 46 hips (49.5%) previously underwent Chiari pelvic osteotomy because of insufficient femoral head coverage. The control group was composed of 36 patients (48%), i.e. 47 hips (50.5%), in whom the degenerative disease also developed as the consequence of insufficient femoral head coverage but where no attempt was made to improve anatomic correlations by surgery. All total hip arthroplasties were performed at the Institute of Orthopedic Surgery (IOS) „Banjica" in the period from 1990 and 2009.

In the study we used only complete and with fully conducted follow-up medical records and radiographies of the pelvis and hips in antero-posterior direction in standing position. In the evaluation of patient's functional status Harris Hip Score was applied (24).

Immediately after the Chiari procedure, using radiographies of the pelvis with hips in the antero-posterior direction, we also measured and calculated osteotomy parameters: osteotomy angle, percentage of medial displacement of inferior pelvic fragment at the level of the osteotomy and the distance of the osteotomy from the acetabular edge. After performed total hip arthroplasty, the acetabular component abduction angle was measured, as well as the distance between its distal edge and the acetabular teardrop.

In all Chiari pelvic osteotomies the original surgical technique was respected (2). In nine patients (19.6%) the occurrence of postoperative complications were recorded. The most frequent problem presented hardware breakage (55.6%), while osteotomy non-union, femoral head avascular necrosis, wound healing delay and joint contracture were equally represented (11.1%).

All surgical implantations of noncemented total hip endoprosthesis were performed via a posterolateral approach. We used various primary implant models with noncemented fixation available in a corresponding time period.

All observed and calculated parameters were used in the formation of database and further statistical analysis. Descriptive statistical methods and methods for statistical hypothesis testing were used in the analysis of primary data. Statistical hypothesis testing involved the use of t-test, χ^2 test, Fisher test of exact probability, Wilks'Lambda test and variance of repeated measurements analysis (ANOVA). Statistical hypotheses were tested at the level of statistical significance of 0.05.

RESULTS

Of 93 operated hips only one (1.1%) belonged to a male patient who had previously undergone Chiari pelvic osteotomy. In the study lower extremities were approximately equally represented (47 right, 46 left), while arthroplasty was performed bilaterally in 18 patients (in 7 patients after Chiari osteotomy and in 11 control group patients). There was no statistically significant difference in the frequency of bilateral incidence of lower extremities between the two studied groups ($\chi^2 = 0.529$; $p = 0.467$).

The mean patient's age at the time of performed Chiari pelvic osteotomy was 37 ± 9.4 years. The youngest patient was aged 15 years and the oldest one 52 years.

Fig. 1. Severe hip arthrosis 15 years after bilateral Chiari osteotomies.

Fig. 2. Bilateral total hip arthroplasty performed 16 years after Chiari pelvic osteotomies. Acetabular cup positions are in the „safe zone" as described by Lewinnek with HHS above 90 bilaterally. Follow-up period of 4 years and 9 months after last surgery.

The mean pelvic osteotomy angle was 10.3 ± 8.6 degrees. In five (10.9%) patients osteotomy was performed completely horizontally (0°), while in one case the maximal determined value was 38 degrees. The mean value of femoral head medialization obtained after Chiari procedure rated 41.5 ± 11.3%. The lowest recorded medialization was 20% and the highest 66.7%. The mean distance from the osteotomy site to the acetabular edge was 10.5 ± 5.8 mm. The greatest measured distance of 26 mm was present in one patient. During triple surger-

ies (6.5%) osteotomy was initiated at the very acetabular edge through the joint capsule. No case of joint penetration was recorded.

The calculated mean time elapsed from the Chiari procedure to the implantation of total hip endoprosthesis was 194.2 ± 75.8 months, ranging from 48 to 423 months.

The observed mean patient's age at the time of arthroplasty was 54.6 ± 8.5 years; it rated 53.4 ± 9.5 years in patients who had previously undergone Chiari pelvic osteotomy, i.e. 55.7 ± 7.3 months in the control group patients. By statistical analysis it was determined that there was no significant difference in the mean patient's age at the time of total hip endoprosthesis implantation between the studied groups ($t = 1.306$; $p = 0.195$).

Femoral head autografts were used in 18 (19.35%) arthroplasties; of these, in 8 hips after Chiari pelvic osteotomy (17.4%), i.e. in 10 control group hips of previously unoperated patients (21.3%). No significant difference was determined in the frequency of autograft utilization between the studied groups ($\chi^2 = 0.225$; $p = 0.635$).

During 43 operations (19 times in patients who had previously undergone Chiari procedure, 24 times in previously unoperated patients), the acetabular component of the total hip endoprosthesis was placed at the site of true anatomic position. In 53.8% cases (27 times in patients after Chiari procedure and 23 times in control group patients) the center of rotation of the hip migrated more often proximally in relation to the teardrop (total 47 hips) than distally (in 3 patients previously unoperated by Chiari osteotomy). No statistically significant difference was found between the studied groups in relation to the position of the acetabular component to the acetabular teardrop ($\chi^2 = 0.891$; $p = 0.345$). In 10 cases (55.6%) the use of bone autograft resulted in the anatomically desired position of the acetabular component, but statistical significance of its utilization was not confirmed ($\chi^2 = 0.780$; $p = 0.377$).

The mean distance from the acetabular component distal edge to the acetabular teardrop was 7.1 ± 9.6 mm. In 18 cases the use of bone graft decreased this distance to 4.7 ± 7.7 mm, but without statistical significance ($t = 1.158$; $p = 0.250$). In the patients previously operated on by the Chiari method the center of rotation of the hip was on the average positioned more proximally (9.8 ± 11.1 mm; the most proximal position was measured 43 mm from the acetabular teardrop), while in the control group of patients acetabular component position was closer to the anatomic one (4.5 ± 6.9 mm; ranging from 3 mm below the acetabular teardrop to 24 mm above the acetabular teardrop). There was a significant difference between the studied groups in relation to the distance between the acetabular component of the endoprosthesis and the acetabular teardrop ($t = -2.763$; $p = 0.007$). By using the bone autograft, the center of rotation of the hip was positioned even closer to that of the true acetabular position (5.9 ± 7.1 mm in the patients previously operated on by the Chiari method, i.e. 3.8 ± 8.5mm in the control group patients). There was no confirmed statistical significant difference in the frequency of autograft use and the distance from the acetabular component to the acetabular teardrop ($t = 1.055$; $p = 0.297$ in the group of patients operated on by the Chiari method, i.e. $t = 0.373$; $p = 0.711$ in the group of previously unoperated patients).

The mean value of the acetabular component abduction angle was 43.6° ± 9.3° In the group of patients previously operated by Chiari osteotomy the mean abduction angle of the acetabular component was 41.8° ± 9.8°, while in the control group it was on the average higher (45.4° ± 8.6°). There was no significant difference in the mean acetabular component abduction angle of endoprosthesis between the studied groups of patients ($t = 1.878$; $p = 0.064$). In 18 cases autograft use slightly decreased acetabular component abduction angle (43.3° ± 6.8°), but without statistical significance ($t = 0.130$; $p = 0.897$).

In all 93 patients the mean value of HHS before the implantation of hip endoprosthesis was 51.9 ± 12.7, and after performed surgery and rehabilitation it was 83.0 ± 11.1. In the patients who had previously undergone Chiari osteotomy even more increased improvement of the functional status was observed (from 46.5 ± 12.0 preoperatively to 84.0 ± 13.4 postoperatively). In the previously unoperated patients the mean value of HHS before hip endoprosthesis implantation was 57.2 ± 11.1. Postoperative functional status after rehabilitation period was improved to mean values of 82.1 ± 8.3. There was a statistically significant increase of postoperative HHS values in both patient groups (Wilks'Lambda = 0.170; $p < 0.001$). In the observed time period there was a statistically significant difference in the HHS values between the studied groups ($F = 5.663$; $p = 0.019$). There was a statistically significant interaction in the patients operated on by Chiari osteotomy and previously unoperated patients in relation to HHS values during the observed period (Wilks'Lambda = 0.833; $p < 0.015$).

After implantation of hip endoprosthesis the patients were under clinical follow-up for the mean 66.6 ± 38.3 months. The shortest follow-up period was 36 and the longest 222 months.

DISCUSSION

Surgical procedure of Chiari's capsular arthroplasty has been applied, more or less frequently, for over 50 years. In the up-to-date orthopaedic practice Chiari pelvic osteotomy is considered a good alternative to total arthroplasty in patients with dysplastic hips and poor joint incongruence, particularly in the adolescent period (13, 14, 28).

Insufficiently good anatomic correlations between the femoral head and acetabulum nevertheless lead to the development of degenerative hip diseases in these patients. It has been observed that the implantation of total endoprosthesis after a previously performed Chiari osteotomy increases with the a longer follow-up period (Ito – 9% after 20.3 years, Kotz – 40% after 32 years) (14, 19). Decreased possibility of sufficient quality and long-term clinical follow-up of patients operated on by Chiari osteotomy most probably represents the major reason of

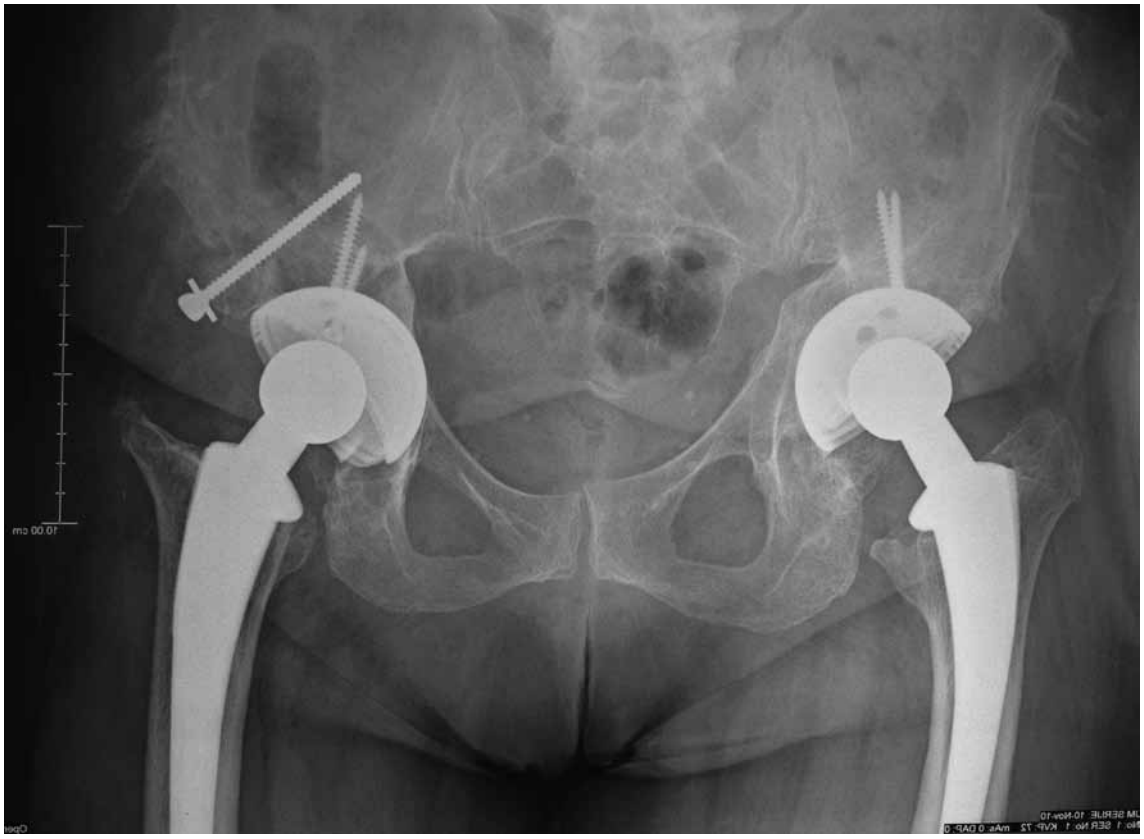

Fig. 3. Total hip arthroplasty performed 15 years after Chiari pelvic osteotomies. Bulk femoral head autograft was used during right hip arthroplasty. Acetabular cups positions are without any significant differences. HHS = 90, follow–up period of 7 years.

Fig. 4. Left hip osteoarthrosis 24 years after Chiari pelvic osteotomy. Right hip arthrodesis is evident.

such a low number of articles dealing with the problems of delayed implantation of total hip endoprosthesis. The group of 39 patients, i.e. 46 hips treated at the IOS "Banjica" over the past 22 years represents the largest group among those we have found in the up-to-date literature.

The mean age of patients at the time of Chiari pelvic osteotomy in our series was 37.0 years, which is significantly higher in relation to other similar studies (8, 14). Such data is not surprising having in mind that only patients who underwent implantation of total hip endoprosthesis are presented. In the study, conducted at the IOS „Banjica" which involved 86 patients (99 hips) of adolescent age ranging from 10–19 years, no case of hip arthroplasty was observed after Chiari pelvic osteotomy (28).

By analysis of obtained results in our series, it can be observed that the osteotomy angle and the distance between the site of osteotomy initiation and acetabular edge was wider, while the percentage of medialization was lower if compared to similar studies conducted in adolescent patients (28, 17). Those are exactly these differences that can explain different anatomic characteristics of bone and soft tissues among different age groups (thicker joint capsule, stronger and less elastic pelvic ring).

In our study the mean time between Chiari pelvic osteotomy and implantation of total hip endoprosthesis was 16.2 years. Ito et al. reported practically identical data (16.4 years), while other authors reported a considerably longer time period (Ohashi et al. 25 years, Kotz et al. 26 years) (14, 19, 24). Nevertheless, a delay in exchanging the biological joint with an artificial one of over 15 years should not be considered failure, particularly if Chiari's capsular arthroplasty is indeed utilized as the salvage procedure in cases where a significant anatomic improvement by the use of some other pelvic osteotomy is not expected.

The mean age at the time of total hip arthroplasty was nor statistically significantly different between the two groups of patients. On this basis it is possible to conclude that Chiari osteotomy considerably prolongs the time of biological hip longevity and that, if performed correctly and timely, it enables a relatively favorable outcome in patients with insufficient femoral head coverage. Such a conclusion is of major significance, particularly if also kept in mind the patient's poor functional status immediately prior to performed Chiari pelvic osteotomy (HHS = 62.6 ± 14.2).

Fig. 5. Total hip arthroplasty of the left hip. Medial cotyloplasty of the acetabulum was performed. Follow-up period of 3 years with HHS = 83.

Bulk autografts are often used in arthroplastic surgery of the hip with the basic goal of providing a good and reliable bearing for the acetabular component of endoprosthesis. Numerous authors insist on the reconstruction of the anatomic centre of rotation of the hip, with or without autograft, which decreases the possibility of accelerated polyethylene and alumina ceramic insert wear and the consequent implant loosening (3, 5, 6, 18, 25, 31). Georgiades et al. has proved increased frequency of loosening of the femoral component of endoprosthesis if the acetabular cup is placed more proximally than 25 mm in relation to the acetabular teardrop (9). Bicanic et al. reported that longitudinal load on the acetabular cup increases by 0.1% for each millimeter of its proximal migration in relation to the position of the true acetabulum (1). Schofer et al. consider that the autograft transplant and later loosening can be expected in approximately 50% of cases after 11.8-year period. The authors consider that the reconstruction of the anatomic rotation centre of the hip, bone quality, graft orientation and screws used for its fixation are the main factors which provide longevity of the noncemented acetabular component of total hip endoprosthesis positioned with the aid of autograft (26). Kim et al. insist on the achievement of the primary initial stability of the implant and the use of a component of the largest possible diameter (18).

It should not to be discarded that there is a number of published papers by authors reporting the opinion that the use of bone

autografts in dysplastic degeneratively altered hips is not justified (12, 16, 18). Positioning the centre of hip rotation more proximally in relation to the true anatomic position (Kim et al. defines the position of high hip centre as the position that is over 35 mm more proximal in relation to the acetabular teardrop) is considered a more favorable and permanent solution if primary stability and sufficient bone coverage of the implant can be achieved (18). Wan et al. report that the distance between the acetabular component and acetabular teardrop has no influence on the wear speed of polyethylene and ceramic inserts of hip endoprosthesis (29).

In our series, bulk structural bone autografts were used in approximately 20% patients, more or less identically in both groups of patients. In this way the anatomically desired position of the acetabular component was achieved in over 50% of cases (Fig. 3). Nevertheless, according to statistical analysis the use of bone grafts in order to place the acetabular cup into the bearing created at the site of the true acetabulum is not justified. Statistical analysis indicates that by increasing the frequency of autograft utilization such a conclusion could be different and in accordance with the reports in the literature (3, 5, 18, 25, 26, 30, 31). In our study, neither autograft resorption nor loosening of the acetabular cup placed in close proximity to the bone graft was recorded. Regarding the position of the acetabular component of endoprosthesis in relation to the acetabular teardrop, there was no statistically confirmed significant difference between the two groups. Nevertheless, it was noted that a slightly higher number of anatomically precisely positioned implants was present in the group of previously unoperated patients. The mean distance between the acetabular component distal edge and the acetabular teardrop was considerably greater in the patients operated by Chiari pelvic osteotomy (9.8 mm). In the control group of patients this distance was 4.5 mm, which is considerably lower compared to the data published in the literature (6, 16, 18, 23). In a study, Fousek J. recorded that in patients with a degenerative disease, following a congenital disorder of the hips, the acetabular component was on the average positioned by 15 mm more proximally in relation to the acetabular teardrop (7).

Undoubtedly, acetabular anatomy, after Chiari pelvic osteotomy, can be the aggravating factor in the proper positioning of the acetabular component of hip endoprosthesis (Figs 4 and 5).

Over 30 years ago Lewinnek identified a „safe zone“ in positioning of the acetabular component of total hip endoprosthesis in order to lower the risk of postoperative hip dislocation (21). Numerous papers have confirmed the original hypothesis according to which it should be insisted that the acetabular cup is to be placed in 40° ± 10° abduction and 15° ± 10° anteversion (4, 32). According to the recent reports, abduction of over 45° is considered responsible for increased wear of polyethylene inserts (4, 9, 29). In patients included in our study, the acetabular component was positioned by free-hand technique. The calculated values of abduction implant did not significantly differ between the two groups of patients and were positioned within the recommended range. These results are in accordance with similar studies (20). It is interesting to mention that in 18 cases the use of autograft did not significantly alter the values of the acetabular component abduction of endoprosthesis. The altered acetabular anatomy has more influence on the height of the acetabular cup in relation to the teardrop than on its abduction.

According to most authors, altered acetabular anatomy after Chiari pelvic osteotomy does not represent a significant problem in arthroplastic joint reconstruction surgery (11, 24, 27). Based on 10 implanted hip endoprostheses, Minoda et al. reports that the recorded prolonged time of surgery involves higher intraoperative blood losses as well as a poorer position of acetabular components (22).

By the implantation of total hip endoprosthesis and later rehabilitation, the functional status of patients with degenerative disease of the dysplastic hip is considerably improved. Preoperative and postoperative values obtained in our study are within the range recorded in the up-to-date literature dealing with similar topic (5, 23, 30). Johansson et al. points out that, after the implantation of total hip endoprosthesis, better functional results have been achieved in patients with a higher preoperative HHS (15). The author suggests a timely surgical intervention so as to provide best possible postoperative function. Results published by Fousek et al. are contrary to the aforementioned data (7). According to his study, after the implantation of total hip endoprosthesis patients with poorer preoperative functional status had higher HHS values (HHS = 38.6 preoperatively, 80.3 postoperatively in group I; HHS = 35.5 preoperatively, 84.9 postoperatively in group II). Similar results were also recorded by analysis and processing of our data. After the implantation of total hip endoprosthesis the patients had a considerably higher functional improvement (HHS from 46.5 preoperatively to 84.0 postoperatively) in relation to the control group of previously unoperated patients (HHS from 57.2 preoperatively to 82.1 postoperatively). Such results confirm the significance of technically properly performed arthroplasty, by which, despite preoperative anatomic relations of different complexity, a practically equally favorable postoperative outcome can be achieved. In the process of making conclusions one should not leave out the fact that the preoperative functional status of patients operated on by the Chiari method was considerably inferior in relation to the group of patients who had not previously undergone surgical treatment.

CONCLUSION

Chiari pelvic osteotomy postpones degenerative processes in patients with insufficient femoral head coverage but it also considerably changes anatomy of the acetabulum. Positioning of the acetabular component during a delayed arthroplasty is not compromised by such anatomic changes. The use of bulk bone autographs decreases the distance between the centre of rotation of the hip and the acetabular teardrop, but it does not have influence on the abduction of the acetabular cup.

References

1. BICANIC, G., DELIMAR, D., DELIMAR, M., PECINA, M.: Influence of the acetabular cup position on hip load during arthroplasty in hip dysplasia. Int. Orthop., 33: 397–402, 2009.
2. CHIARI, K.: Medial displacement osteotomy of the pelvis. Clin. Orthop. Relat. Res., 98: 55–71, 1974.
3. DAPUZZO, M. R., SIERRA, R. J.: Acetabular considerations during total hip arthroplasty for hip dysplasia. Orthop. Clin. North Am., 43: 369–375, 2012.
4. EPSTEIN, N. J., WOOLSON, S. T., GIORI, N. J.: Acetabular component positioning using the transverse acetabular ligament: can you find it and does it help? Clin. Orthop. Relat. Res., 469: 412–416, 2011.
5. ERMIŞ, M. N., DILAVEROĞLU, B., ERÇELTIK, O., TUHANIOĞLU, U., KARAKAŞ, E. S., DURAKBAŞA, M. O.: Intermediate-term results after uncemented total hip arthroplasty for the treatment of developmental dysplasia of the hip. Eklem Hastalik Cerrahisi, 21: 15–22, 2010.
6. FLECHER, X., PARRATTE, S., BRASSART, N., AUBANIAC, J. M., ARGENSON, J. N.: Evaluation of the hip center in total hip arthroplasty for old developmental dysplasia. J. Arthroplasty, 23:1189–1196, 2008.
7. FOUSEK, J., INDRÁKOVÁ, P.: Total hip arthroplasty in post-dysplastic hip arthritis. Can type and position of the acetabular component influence longevity of the prosthesis? Acta Chir. orthop. Traum. čech., 74: 47–54, 2007.
8. GAGAŁA, J., BLACHA, J., BEDNAREK, A.: Chiari pelvic osteotomy in the treatment of hip dysplasia in adults. Chir. Narzadow. Ruchu Ortop. Pol., 71: 183–185, 2006.
9. GEORGIADES, G., BABIS, G. C., KOURLABA, G., HARTOFILAKIDIS, G.: Effect of cementless acetabular component orientation, position, and containment in total hip arthroplasty for congenital hip disease. J. Arthroplasty, 25: 1143–1150, 2010.
10. HARRIS, W. H.: 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 Jt Surg., 51-A: 737–755, 1969.
11. HASHEMI-NEJAD, A., HADDAD, F. S., TONG, K. M., MUIRHEAD-ALLWOOD, S. K., CATTERALL, A.: Does Chiari osteotomy compromise subsequent total hip arthroplasty? J. Arthroplasty, 17: 731–739, 2002.
12. HOLZAPFEL, B. M., GREIMEL, F., PRODINGER, P. M., PILGE, H., NÖTH, U., GOLLWITZER, H., RUDERT, M.: Total hip replacement in developmental dysplasia using an oval-shaped cementless press-fit cup. Int. Orthop., 36: 1355–1361, 2012.
13. ITO, H., MATSUNO, T., MINAMI, A.: Chiari pelvic osteotomy for advanced osteoarthritis in patients with hip dysplasia. J. Bone Jt Surg., 87-A: Suppl. 1(Pt 2): 213–225, 2005.
14. ITO, H., TANINO, H., YAMANAKA, Y., NAKAMURA, T., MINAMI, A., MATSUNO, T.: The Chiari pelvic osteotomy for patients with dysplastic hips and poor joint congruency: long-term follow-up. J. Bone Jt Surg., 93-B: 726–731, 2011.
15. JOHANSSON, H. R., BERGSCHMIDT, P., SKRIPITZ, R., FINZE, S., BADER, R., MITTELMEIER, W.: Impact of preoperative function on early postoperative outcome after total hip arthroplasty. J. Orthop. Surg. (Hong Kong), 18: 6–10, 2010.
16. KANEUJI, A., SUGIMORI, T., ICHISEKI, T., YAMADA, K., FUKUI, K., MATSUMOTO, T.: Minimum ten-year results of a porous acetabular component for Crowe I to III hip dysplasia using an elevated hip center. J. Arthroplasty, 24: 187–194, 2009.
17. KARAMI, M., FITOUSSI, F., ILHARREBORDE, B., PENNEÇOT, G. F., MAZDA, K., BENSAHEL, H.: The results of Chiari pelvic osteotomy in adolescents with a brief literature review. J. Child. Orthop., 2: 63–68, 2008.
18. KIM, M., KADOWAKI, T.: High long-term survival of bulk femoral head autograft for acetabular reconstruction in cementless THA for developmental hip dysplasia. Clin. Orthop. Relat. Res., 468: 1611–1620, 2010.
19. KOTZ, R., CHIARI, C., HOFSTAETTER, J. G., LUNZER, A., PELOSCHEK, P.: Long-term experience with Chiari's osteotomy. Clin. Orthop. Relat. Res., 467: 2215–2220, 2009.
20. KUMAR, J. N., KUMAR, J. S., WANG, V. T., DAS DE, S.: Medium-term outcome of total hip replacement for dysplastic hips in Singapore. J. Orthop. Surg., (Hong Kong) 18: 296–302, 2010.
21. LEWINNEK, G. E., LEWIS, J. L., TARR, R., COMPERE, C. L., ZIMMERMAN, J. R.: Dislocations after total hip-replacement arthroplasties. J. Bone Jt Surg., 60-A: 217–220, 1978.
22. MINODA, Y., KADOWAKI, T., KIM, M.: Total hip arthroplasty of dysplastic hip after previous Chiari pelvic osteotomy. Arch. Orthop. Trauma Surg., 126: 394–400, 2006.
23. MURAYAMA, T., OHNISHI, H., OKABE, S., TSURUKAMI, H., MORI, T., NAKURA, N., UCHIDA, S., SAKAI, A., NAKAMURA, T.: 15-year comparison of cementless total hip arthroplasty with anatomical or high cup placement for Crowe I to III hip dysplasia. Orthopedics, 35: e313–318, 2012.
24. OHASHI, H., HIROHASHI, K., YAMANO, Y.: Factors influencing the outcome of Chiari pelvic osteotomy: a long-term follow-up. J. Bone Jt Surg., 82-B: 517–525, 2000.
25. SHETTY, A. A., SHARMA, P., SINGH, S., TINDALL, A., KUMAR, S. V., RAND, C.: Bulk femoral-head autografting in uncemented total hip arthroplasty for acetabular dysplasia: results at 8 to 11 years follow-up. J. Arthroplasty, 19: 706–713, 2004.
26. SCHOFER, M. D., PRESSEL, T., SCHMITT, J., HEYSE, TJ., BOUDRIOT, U.: Reconstruction of the acetabulum in THA using femoral head autografts in developmental dysplasia of the hip. J. Orthop. Surg. Res., 6: 32, 2011.
27. TOKUNAGA, K., ASLAM, N., ZDERO, R., SCHEMITSCH, E. H., WADDELL, J. P.: Effect of prior Salter or Chiari osteotomy on THA with developmental hip dysplasia. Clin. Orthop. Relat. Res., 2011; 469: 237–243, 2011.
28. VUKAŠINOVIĆ, Z., SPASOVSKI, D., SLAVKOVIĆ, N., BAŠČAREVIĆ, Z., ŽIVKOVIĆ, Z., STARČEVIĆ, B.: Chiari pelvic osteotomy in the treatment of adolescent hip disorders: possibilities, limitations and complications. Int. Orthop., 35: 1203–1208 2011.
29. WAN, Z., BOUTARY, M., DORR, L. D.: The influence of acetabular component position on wear in total hip arthroplasty. J. Arthroplasty, 23: 51–56, 2008.
30. WU, L. D., JIN, L. B., YAN, S. G., YANG, Q. S., DAI, X. S., WANG, X. H.: Total hip arthroplasty with cementless cups and femoral head autografts for patients with hip dysplasia and osteoarthritis. Chin. J. Traumatol., 7: 280–285, 2004.
31. YANG, S., CUI, Q.:. Total hip arthroplasty in developmental dysplasia of the hip: Review of anatomy, techniques and outcomes. World J. Orthop., 3: 42–48, 2012.
32. YOON, Y. S., HODGSON, A. J., TONETTI, J., MASRI, B. A., DUNCAN, C. P.: Resolving inconsistencies in defining the target orientation for the acetabular cup angles in total hip arthroplasty. Clin. Biomech. (Bristol, Avon) 23: 253–259, 2008.

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