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Some Aspects of Total Hip Replacement with Subtrochanteric Shortening Osteotomy in Patients with Congenital Hip Dislocation (Review)

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Abstract

Total hip replacement (THR) in patients with a high congenital dislocation of the hip (Crowe type IV dysplasia in Crowe classification) is a technically difficult operation, associated with a high risk of complications. The most common variations of THRs used to restore the true center of rotation of the hip are subtrochanteric shortening osteotomy and proximal shortening osteotomy using the Paavilainen technique. Numerous publications refer to the technique and outcomes of subtrochanteric osteotomy, but fundamental differences of opinion persist on a number of points relating to the topic. ***The objective of the study*** is to analyze the publications on the treatment for Crowe type IV hip dislocations using total replacement of the hip joint (HJ) with subtrochanteric shortening osteotomy. ***The hypothesis of the study*** was as follows: the method of fixation of the femoral component, the type of osteotomy and the design features of the implant (philosophy) are the factors that determine the effectiveness of the operation. The electronic databases eLibrary and PubMed were searched for publications containing keywords in Russian or English: high dislocation of the hip, total replacement of the HJ, shortening subtrochanteric osteotomy. As a result of the study, the proposed hypothesis was partially confirmed. There were only minor differences in the overall incidence of complications and the survivorship of implants when using different types of cementless stems. The incidence of non-unions after the installation of cemented femoral components was higher than with the implantation of cementless. We did not find convincing evidence of the advantage of the step-cut, V-shaped and oblique osteotomies compared with the transverse osteotomy. Typical complications for such operations were the nerve injuries, intraoperative hip fractures, dislocations and non-unions of the femur at the osteotomy site.

Keywords: high hip dislocation, total hip replacement, shortening subtrochanteric osteotomy.

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The literature presents various data on the rate of developmental hip dysplasia among all patients who underwent total hip replacement (THR).

Krych et al. described the outcomes of 8848 THRs performed at the Mayo clinic from 1992 to 2005. In 46 cases, Crowe type IV dysplasia was recorded. Simultaneous shortening osteotomy was required in 37 cases. Thus, among a total number of patients admitted for THR, the pathology was found in 0.52% of cases, and 0.41% of patients needed shortening osteotomy [1].

According to the Norwegian Arthroplasty Register, from 1987 to 2003, 84871 THRs were performed, of which 7.5% were related to developmental dysplasia of the hip (DDH), including hip dysplasia with dislocation — 0.9% (788 operations) [2].

After retrospectively assessing 1226 hip arthroplasties, Zhu et al. determined that in 20 cases (1.6%) a Crowe type IV hip dislocation was the reason for a shortening osteotomy [3].

In the paper of Japanese orthopedists, a Crowe type IV dysplasia was detected in 36 cases (2.3%) among 1521 primary THRs. Subtrochanteric osteotomy was required in 12 cases (0.78%) [4].

However, in patients with high hip dislocation, it is possible to implant the endoprosthesis without resorting to a shortening osteotomy. For the reduction of the hip, it is necessary to carefully remove the osteophytes and the fragments of the capsule around the cavity, as well as to partially dissect the rectus femoris and adductor muscles. During surgery, muscle relaxants should be used in sufficient dose [5]. Also, some authors describe methods of two-stage arthroplasty using an external fixation device as well as other types of osteotomies [6–9]. Besides subtrochanteric osteotomy, the most common is proximal shortening osteotomy by Paavilainen [10].

The results of the above studies indicate that the proportion of patients with high hip dislocation is not large even in specialized clinics. However, the THR in such patients seems to be a difficult task for the orthopedic surgeons, since it is necessary to restore the true center of rotation and at the same time to avoid neurological complications [11–14].

The purpose of the study — to analyze the publications on the treatment for Crowe type IV hip dislocations using total replacement of the hip joint (HJ) with subtrochanteric shortening osteotomy.

The hypothesis of the study was as follows: the method of fixation of the femoral component, the type of osteotomy and the design features of the implant (‘philosophy’) are the factors that determine the THR effectiveness. Typical complications for such operations are: nerve injuries (sciatic, femoral, obturator, etc.), dislocations and fractures. The electronic databases of eLIBRARY and PubMed were searched for publications in Russian and English using keywords: high hip dislocation, total hip replacement (THR), shortening subtrochanteric osteotomy, Crowe 4 DDH replacement.

The advantages and disadvantages of the cemented and cementless femoral component fixation. Most surgeons preferred to use cementless stems after performing a shortening osteotomy [12, 15–21]. This choice was due to the young age of the patients and the desire to prevent cement particles between osteotomized hip fragments [12, 18, 19, 21]. For cement hip arthroplasty with a shortening osteotomy, it is important to avoid the penetration of cement between the fragments of the femur and preserve the periosteum as much as possible. With cement fixation, the penetration of cement into the femoral canal reduces the number of bone marrow cells and reduces the regenerative potential of the endosteum [20, 21]. Moreover, radiographs showed the presence of cement between the end surfaces of the fragments, which impaired consolidation [20, 22]. However, the fixation of autografts over the osteotomy site using cerclages allowed, for example, Kawai et al. and Oe et al. to cite the achievement of consolidation even with the penetration of cement into the osteotomy site [22, 23].

The significant advantages of the cement fixation method include the primary stability, which occurs immediately after cement polymerization and contributes to the consolidation of fragments [22]. Takao et al. and Bruce et al. successfully used cementless modular components, but noted that with poor bone quality and a short sawn neck, the use of cement fixation is preferable [24, 25].

Several research teams are of the opinion that the use of cemented femoral components reduces the risk of fractures during canal treatment and stem implantation [15, 16, 18, 25]. Indeed, the incidence of intraoperative femur fractures can reach up to 20% [12, 16, 17, 25]. However, the tight insertion of the cementless stems is necessary to achieve primary fixation, and most of the fractures successfully grow together after additional fixation using the cerclages [16]. When analyzing the literature, we found a large number of successful trials with cementless femoral components [3, 12, 21, 16, 17, 26–29].

Rollo et al. published the results of 17 cementless arthroplasties with 100% survivorship for 7.3 years. According to the authors, the femoral canal in patients with dysplasia is narrow. This can lead to the use of very small components or inadequate mantle thickness, which in turn can cause aseptic instability or even fatigue fractures of components [12, 21, 30].

Table 1 confirms the trend identified above: cemented stems are used less frequently [15, 18, 20, 23, 31] than cementless [3, 4, 12, 16–18, 21, 24–29, 31–35].

Notes and abbreviations. Approach: Harding — direct lateral approach; Watson-Jones — anterolateral approach. L — length of the excised bone segment. Method of femoral component fixation: cemented; cementless. Femoral stem: S-Rom — S-Rom modular femoral components (DePuy); Wagner — Wagner standard conical femoral components; Zweymuller — straight, tapered femoral components with a rectangular cross-section, monoblock — standard monoblock femoral components. Complications: hip fracture — intraoperative periprosthetic fracture of the femur that did not require component replacement or revision; fracture of the acetabulum — intraoperative fracture of the acetabular cup; neuritis — injury of the sciatic or femoral or other nerves, venous thrombosis — deep vein thrombosis ; periprosthetic fracture — periprosthetic fracture that occurred after the operation and required a revision with the replacement of the component; infection — deep periprosthetic infection; deterioration or wear of the polyethylene liner — severe wear of the polyethylene liner which required a revision operation with its subsequent replacement.

Choice of femoral component. Analysis of the data presented in Table 1 shows that, when performing a THR with subtrochanteric osteotomy, cementless monoblock stems [1, 3, 12, 16, 17, 21, 26, 27, 28, 29, 32, 33, 34, 36] and S-Rom modular stems [1, 4, 12, 24, 25, 31, 34, 35] were used most often. Among monoblock stems, tapered stems were most frequently mentioned [12, 16, 32, 34]. The advantages of this stem type were convenient positioning, stability of fixation and a good load distribution [12, 32, 37].

Can et al., after performing 66 osteotomies, noted a slow consolidation in 2 cases, one of which required a reoperation with femoral component replacement. If the surgeon doubted the fixation stability, cerclages or trochanteric plates with cable systems were used [32].

Park, M.S. used modular, monoblock tapered and revision stems for distal fixation. Postoperative follow-up revealed non-union in 3 patients with a tapered stem and additional plate fixation, whereas patients with modular stems did not experience such complications [34].

Table 1

Features of surgical technique during THR in patients with DDH and complications' rate Aggregate data of 24 papers (738 cases)

Authors and year of publication	No. of cases	Approach	Osteotomy	L (cm)	Fixation	Femoral stem	Leg lengthening (cm)	Union period (months)	Complications
Bruce W.J.M. et al., 2000 [25]	9	Harding	Transverse	1.7	Cementless	S-Rom	4	3	1 dislocation, 1 periprosthetic fracture
Sener M. et al., 2002 [21]	28	Harding and Watson-Jones	Step-cut	3.5	Cementless	Monoblock		10	3 neuritis, 1 acetabular cup fracture
Masonis J.L. et al., 2003 [31]	21	Posterior and Harding	Transverse	3.8	Cemented and cementless	S-Rom and standard cemented	2.5	6	3-dislocations, polyethylene liner deterioration
Erdemli B. et al., 2005 [29]	25	Harding and Watson-Jones	Transverse	4.2	Cementless	Monoblock	3.7		1 neuritis, 3 hip fractures, 1 venous thrombosis
Bernasek T. et al., 2007 [35]	30	Posterior	Transverse	3.2	Cementless	S-Rom	1.38		4 dislocations, wear of 4 polyethylene liners
Park M.S. et al., 2007 [34]	24	Watson-Jones and posterior	Transverse		Cementless	S-Rom, Zweymuller and revision stems		3.2	3 hip fractures, 1 dislocation
Krych A. et al., 2009 [1]	28	Posterior	Transverse	4	Cementless	Monoblock and S-Rom			6 fractures, 3 dislocations
Howie C.R. et al., 2010 [15]	33	Posterior	Transverse	2.4	Cementless	Cemented			2 neuritis, 3 dislocations, 2 periprosthetic fractures, 1 infection
Takao M. et al., 2011 [24]	33	Posterior	Step cut	4.1	Cementless	S-Rom	1.9		2 dislocations, 8 hip fractures
Charity J.A et al., 2011 [18]	18	Posterior	Transverse	3	Cemented and cementless	Cemented	3		1 neuritis
Kiliçoğlu Oİ et al., 2013 [28]	20	Harding	Oblique	4.5	Cementless	Cylindrical and Wagner	3.5	4	3 dislocations, 3 hip fractures
Oe K. et al., 2013 [23]	34		Transverse		Cemented	Cemented	40.5	7.7	3 dislocations

Oinuma K. et al., 2014 [4]	12	Anterior	Transverse	2.5	Cementless	S-Rom	3.5		1 dislocation
Sofu H. et al., 2015 [26]	73	Posterior	Transverse	3.5	Cementless	Monoblock		5.2	1 dislocation, 1 infection
Zhu J. et al., 2015 [3]	21	Posterior	Transverse	1.5	Cementless	Wagner	3.8	5	3 neuritis, 1 dislocation
Eid A. et al., 2015 [17]	14	Posterior	Oblique	2	Cementless	Monoblock			–
Akiyama H. et al., 2015 [20]	15	Watson-Jones	Transverse	3.8	Cemented	Cemented	2.7	9.2	2 dislocations
Mu W. et al., 2016 [16]	71	Posterior	Transverse		Cementless	Zweymuller	1.83		1 dislocation, 7 neuritis, 15 hip fractures, wear of 4 polyethylene liners
Ozan F. et al., 2016 [27]	32	Posterior	Transverse	3.2	Cementless	Monoblock	3.1	7.2	5 hip fractures, 3 dislocations, 1 varus deformity at the osteotomy site
Ollivier M. et al., 2016 [33]	28	Posterior and Watson-Jones	Transverse	4	Cementless	Round porous-coated stem		10	3 dislocations, 5 hip fractures
Can A. et al., 2017 [32]	52	Posterior	Transverse	3.5	Cementless	S-Rom		8	2 dislocations, 2 neuritis, 3 venous thrombosis
Zeng W.N. et al., 2017 [38]	69	Watson-Jones	Transverse	3.7	Cementless	Zweymuller			1 dislocation, 3 neuritis, 1 non-union, 1 hip fracture, 1 acetabular cup fracture
Rollo G. et al., 2017 [12]	17	Harding	Transverse, step cut	3.9	Cementless	S-Rom and Zweymuller	3.3	3	1 hip fractures, 2 neuritis
Altay M. et al., 2018 [36]	41	Harding	Transverse		Cementless	Monoblock	1.4		3 dislocations
Average	31±2.7	–	–	3.3±0.15	–	–	2.9±0.2	6.2±0.6	–

It should be recognized that the S-Rom modular femoral components are most widely used when performing the above operations [1, 4, 12, 24, 25, 31, 34, 35, 38–40]. The S-Rom components are cementless modular cylindrical stems, theoretically providing maximum coverage in the proximal and distal parts [38, 41]. The hydroxyapatite or porous coating of the proximal sleeve does not cause the development of stress shielding and isolates the intramedullary canal from debris. Zeng, W.N., evaluating the outcomes of 52 THRs using modular implants, concluded that the S-Rom femoral component is the best option for primary THR in patients with high hip dislocation. The presence of the proximal sleeve and the distal segment with polished grooves provides primary stability even without additional fixation, and the proximal segment rotating 360° helps to easily eliminate excessive anteversion [12, 38]. However, despite the obvious advantages of these implants, they are quite expensive, and operations with them, according to some orthopedists, are technically complex [3, 24, 42]. In addition, the risk of fretting corrosion cannot be excluded, which can lead to osteolysis and an increase in the level of metal ions in the blood [42]. An example of mechanically assisted corrosion (a combination of crevice corrosion and fretting corrosion in conjunction with micro-motion) is detailed in the work of specialists of the R.R.V reden Russian Research Institute of Traumatology and Orthopaedics [43].

In some studies, orthopedists favored Wagner conical stems [3, 28, 44] and cylindrical stems [28]. Zagra, L. used oblique subtrochanteric osteotomy and a conical femoral component when performing 16 total hip arthroplasties. In his opinion, Wagner's stem is the optimal choice for dysplastic hips. Only one patient had a slow consolidation [44].

According to Maratli, K.S., the fixation stiffness at the junction of the fragments after performing oblique osteotomy and using conical stems was statistically significantly greater than when using cylindrical stems [45]. The use of grafts or cables did not affect the fixation stability. On the contrary, according to Yildiz, F., the fixation stiffness in the group with cylindrical stems was slightly higher [20, 46].

The influence of the femoral osteotomy technique on the fixation stability of bone fragments and the femoral component. Many researchers focus their attention on the method of resection and processing the femur, which ensures sufficient stability of the osteotomy site, thereby determining the duration of consolidation of fragments and the success of treatment as a whole. The literature describes transverse, oblique, step-cut (Z-shaped), and double chevron osteotomy [3, 21, 25, 26, 28, 29, 31, 44, 47].

There is a certain pattern detected. The stability between the fitted fragments of the femur is higher after performing the most laborious reconstructive interventions. Complex shaped osteotomy is more difficult technically, but it increases contact between the fragments and reduces the possibility of their rotational displacement. Many researchers consider step-cut osteotomy as the most reliable, but also time-consuming osteotomy [3, 12, 13, 21, 24, 29].

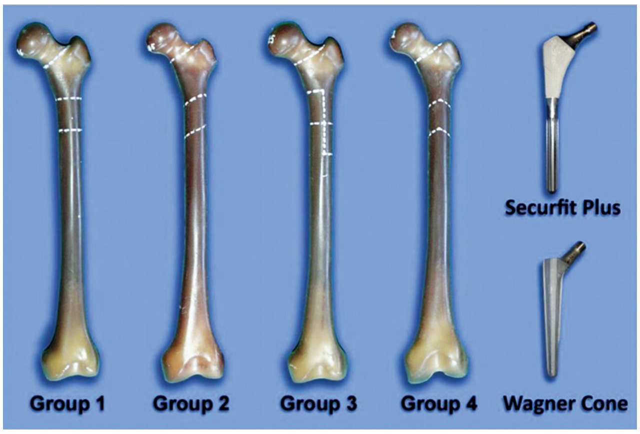

Fig. Types of subtrochanteric shortening osteotomy:
Group 1 — transverse;
Group 2 — oblique;
Group 3 — step-cut;
Group 4 — double chevron (M-shaped) [45]

Rollo, G. performs a step-cut osteotomy whenever possible. According to the author, good bone quality and a BMI of less than 28 determine the use of this method, and in all other cases, transverse osteotomy is preferred [12].

In some studies, it has been noted that transverse osteotomies are less stable under torsion stress [17, 28, 29]. Excessive femoral anteversion in patients with Crowe type IV hip dysplasia can cause dislocations and gait, so osteotomy is performed not only for the purpose of shortening, but also for derotation. The advantage of transverse osteotomy over the oblique and step-cut osteotomies is the ability to change the rotation of the proximal femoral fragment relative to the distal one during the operation [18, 31].

The results of laboratory studies on this issue are ambiguous. Upon experimentation on composite materials, Yildiz et al. and Maratli et al. did not reveal a statistically significant difference in the fixation stiffness [45, 46]. At the same time, after an *in vitro* and *in vivo* study in dogs, Markel et al. showed that the structural fixation stiffness of the femur when using step-cut osteotomy is 36% higher than with transverse osteotomy [48, 49].

According to some reports, the disadvantage of step-cut osteotomies is an increased risk of stress-fractures precisely in the corner zone [46, 48, 50]. One must agree that an increase in the contact zone of the fragments at the osteotomy site increases the ability to consolidate [28, 50, 51]. Orthopedists who practice arthroplasty with oblique osteotomy, believe that this method increases both the contact of fragments and rotational stability, and the simplicity of its implementation compares to a transverse osteotomy [17, 19, 28, 52].

According to a meta-analysis of 37 articles (795 joints) conducted by Li et al., the frequency of non-unions after performing transverse and other types of osteotomies did not significantly differ. However, the performance of modified (step-cut and double chevron) osteotomies increases the complexity and duration of the operation, increasing requirements for surgical team skills and tools [53].

Choice of approach for hip arthroplasty with shortening osteotomy in patients with high hip dislocation. From our study, we identified 3 common approaches used for hip arthroplasties with shortening osteotomy: posterior, direct lateral (Harding) and anterolateral (Watson-Jones). A group of orthopedists from Japan, directed by Oinuma, K., used a direct anterior approach, arguing that maximum muscle preservation and early exercise would contribute to better blood supply to the hip fragments and subsequent consolidation.In addition, this approach is easy to expand proximally or distally without the risk of nerve injury [4]. Generalized data from clinical studies presented in Table 1 indicate that a posterior approach is more popular with orthopedic surgeons [1, 3, 12, 15–18, 24, 26, 27, 31, 33–35, 38] than the anterolateral [20, 21, 29, 32–34] or direct lateral approach [12, 21, 25, 28, 29, 31, 36].

Complications. According to the literature, the frequency of adverse events when performing total hip arthroplasty with subtrochanteric osteotomy is as high as 41% [14]. After examining their nature, we found that dislocations, intraoperative periprosthetic fractures, nerve injuries and non-unions of the femur fragments are the most common complications.

According to the results of our study, the total frequency of complications was 24.4±2% (Table 2).

Table 2

Functional results of hip arthroplasty with subtrochanteric shortening osteotomy and survivorship of endoprosthesis components. Data of 24 papers (738 cases)

Authors	Number of cases	Postoperative follow-up period (years)	Survivor-ship of cup and liner (%)	Survivorship of femoral component (%)	Non-unions (%)	Overall survivorship of endoprosthesis (%)	Overall frequency of complications (%)	Harris Hip Score before THR	Harris Hip Score after THR
Bruce W.J.M. et al., 2000 [25]	9	4.5	–	89	0	89	33	31	81
Sener M. et al., 2002 [21]	28	4	–	93	7	–	18	–	–
Masonis J.L. et al., 2003 [31]	21	5.8	95.3	90.5	9.5	76	28	32.5	73.6
Erdemli B. et al., 2005 [29]	25	5	92.5	96	4	87.5	36	37.8	95
Bernasek T. et al., 2007 [35]	30	8	87	100	0	87	26	42	82
Park M.S. et al., 2007 [34]	24	4.8	96	88	12	85.4	33.3	35.4	81.6
Krych A. et al., 2009 [1]	28	4.8	93	89.3	7	82.3	42	43	89
Howie C.R. et al., 2010 [15]	33	5.6	96	91	3	80	30	–	–
Takao M. et al., 2011 [24]	33	8	–	97	0	97	333	–	–
Charity J.A et al., 2011 [18]	18	9.5	83.3	94.5	5.5	77.5	28	–	–
Kiliçoğlu Oİ et al., 2013 [28]	20	6.8	95	95	5	85	40	33	83
Oe K. et al., 2013 [23]	34	5.2	100	100	0	100	9	–	–
Oinuma K. et al., 2014 [4]	12	3.7	–	100	0	100	8	–	–
Sofu H. et al., 2015 [26]	73	4.8	–	87	5.5	87	12	38.6	83.7
Zhu J. et al., 2015 [3]	21	3.5	–	95	5	95	19	52	90
Eid A. et al., 2015 [17]	14	4.7	93	93	0	86	14	42	86
Akiyama H. et al., 2015 [20]	15	5	–	80	20	80	33	–	–
Mu W. et al., 2016 [16]	71	5.8	91.4	100	0	91.4	49	35.6	83
Ozan F. et al., 2016 [27]	32	5,1	95.8	95.8	3.1	95.8	27.8	49.5	87.1
Ollivier M. et al., 2016 [33]	28	10	96.5	89	7	82	22	43	87
Can A. et al., 2017 [32]	69	3.2	97	98.5	1.5	95.5	16.3	–	–
Zeng W.N. et al., 2017 [38]	52	9.8	100	100	0	100	13	33.7	89.8
Rollo G. et al., 2017 [12]	17	7.3	100	100	0	100	17	38.3	85.6
Altay M. et al., 2018 [36]	41	2.8	95.2	97.6	0	92.7	9.7	–	–
Average	31±2.7	5.7±0.3	95±0.7	94.6±0.9	4.3±0.9	88.7±1.4	24.4±2	36.7±1.3	85.6±0.9

Upon the endoprosthesis cup installation in a true acetabulum in patients with high hip dislocation, the relative length of the limb may increase by 4 cm or more [11, 12, 14, 54]. If it is possible to overcome the resistance of soft tissues and perform the operation in one step, the risk of traction neuropathies will be very high — up to 13% [15, 16]. The shortening osteotomies allow the replacement of a joint without excessive tension of the soft tissues and, as a result, no nerve injuries. However, these operations are associated with the femoral resection and often additional fixation with plates, cable systems and cerclages [16, 17, 18, 21, 23, 25, 26, 33]. Despite excision of a femoral fragment, a lengthening of the leg is noted on average by 2.9±0.15 cm (see Table 1). The above factors are likely to cause nerve injury after hip arthroplasty with shortening osteotomy.

Intraoperative femoral fractures were observed in those studies where a cementless fixation was used [16, 24, 28, 32–34], which is due to the need for a tight insertion of the femoral components. The authors who used cement fixation did not encounter similar problems during the operation [15, 18, 20, 31]. The narrowness of the femoral canal in patients with Crowe IV dysplasia increases the risk of splitting fractures. In most cases, the fracture region is fixed with cerclages [17, 25, 32, 34, 37], less often with extramedullary fixators [26, 29], and does not require repeated interventions. It is interesting that Thilemann, T.M. found that an intraoperative fracture significantly increases the likelihood of revision intervention for dislocation in the first 3 months after THR [55].

Dislocations were noted in most of the articles we studied. According to Pavlov, V.V., dislocation is due to excessive shortening of the femur, but neuropathy is due to an insufficient length of the resected fragment [56]. Altered anatomy of the femur with excessive anteversion also increases the risk of dislocation of the endoprosthesis head. Considering the narrowness of the canal and large anteversion, modular stems with a rotating proximal sleeve can be considered optimal for implantation in patients with dysplasia. If a monoblock component is installed, then shortening-derotational osteotomy may be required [18, 31]. Despite these advantages, even after implantation of S-Rom modular components, dislocations were observed in the joint [24, 25, 27, 35], which indicates multiple factors which may cause this complication.

After analyzing 24 studies (738 cases of THRs) published on this topic, we found that non-unions of the femoral fragments after performing a shortening osteotomy occur with a frequency up to 20%. The total non-union rate was 4.3±0.9% (see Table 2). The main cause of non-union can be considered fixation instability. We believe that the use of cement also reduces the regenerative potential of the bone, as evidenced by the high frequency of non-unions [18, 20, 31].

The conviction of orthopedists for the benefits of step-cut osteotomies has not been adequately confirmed. A retrospective meta-analysis of 37 papers (795 joints) showed that the frequency of non-unions was the same for different types of shortening osteotomies of the femur [39]. Experimental studies have shown that when installing an endoprosthesis with shortening osteotomy of the femur in dogs, consolidation occurred in 100% of cases, regardless of the type of osteotomy. Moreover, animals with transverse osteotomy completely loaded the limb 3 months after surgery and animals with a step-cut osteotomy after 6 months [49]. We found that in studies where cementless stems were used, the overall frequency of complications was 24±2.2%, of non-unions — 3.1±0.9%, and the femoral component survivorship — 95.4±0.8%. For cement implants, the overall frequency of complications was 25.6±3%, of non-unions — 5.4±1.3%, stem survivorship — 91.2±2.1%.

After additional study of publications on the use of modular femoral components, the following results were obtained: the overall frequency of complications was 25.5±3%, of non-unions was 3±1.6%, and the femoral component survivorship was 95±1.8%. Results in the group of tapered implants are similar: overall frequency of complications — 28.5±6%, of non-unions — 3.3±2%, stem survivorship: 96.6±2%.

As a result of the study, the following was concluded.

The hypothesis was partially confirmed. There were only minor differences in the overall frequency of complications and the survivorship of implants when using different types of cementless stems.

The frequency of non-unions when installing cemented femoral components was higher: 5.4±1.3% versus 3.1±0.9%, and the survivorship of the stems themselves was lower than when using cementless components: 91.2±2.1% versus 95,4±0.8%. However, we have too few publications in which the cement fixation was used.

Despite the theoretical advantages of complex shaped osteotomies, there is no convincing evidence of greater fixation stiffness and of lower non-union frequency compared with the transverse resection method. Taking into account the technical difficulty of performing a complex shaped osteotomy, we recommend transverse shortening osteotomy for THR in patients with Crowe type IV dysplasia.

Most authors state that common complications after THR with subtrochanteric shortening osteotomy are neuropathy, intraoperative femoral fractures, dislocations and non-unions of the femur at the osteotomy site. Such adverse events as periprosthetic infection, deep vein thrombosis and periprosthetic fracture in the postoperative period were recorded in only a few works and in isolated cases.

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