Hip dislocation in adolescents and adults with cerebral palsy: palliative methods of surgical treatment (literature review)

R.R. Bidiamshin, D.A. Popkov

FSBI Russian Ilizarov Scientific Center Restorative Traumatology and Orthopaedics of the RF Ministry of Health, Kurgan

The authors present a literature review related to surgical orthopedic treatment of hip dislocation in patients with severe cerebral palsy (GMFCS IV, V) aged 10 years and older. They discuss indications, special features, results, advantages and disadvantages of surgical interventions such as resection arthroplasty of the proximal femur, valgus support osteotomy of the femur, hip joint arthroplasty and arthrodesis.

Keywords: hip dislocation, cerebral palsy, palliative orthopedic surgical interventions

Hip dislocation is one of the most common and heavy complications in patients with severe spastic types of cerebral palsy (CP) accompanied by marked motor disorders (GMFCS IV, V) [1, 2, 3, 4, 5]. The incidence of hip subluxation and dislocation in children with CP ranges from 2.6 to 75 % [1, 3, 6, 7, 8, 9]. Patients with bilateral spastic hemiplegia and severe types of spastic diplegia are most susceptible to such complications [4, 10, 11, 12]. Hip subluxation is encountered in one to 9.5 % of cases with mild and moderate grades of diplegia and in hemiplegia types [13, 14].

Predisposing factors for femoral head lateralization and dislocation is spasticity of the adductors and iliopsoas muscle of the femur, excessive anteversion of the femoral neck and its valgus deformity as well as absent functional loading on the limb [1, 13, 15].

Early reconstructive interventions on soft tissues (in the age between 3 and 9 years) [16, 17, 18] or corrective osteotomy of the femur in combination with the intervention on the tendons and muscles with possible variants of pelvic osteotomies [12, 19, 20] are efficient in cases of femur subluxation and dislocation. It is known that reconstructive interventions on the hip are effective in cases of insignificant femoral head deformities without manifestations of osteoarthritis and open Y-shaped epiphyseal cartilage [21, 22, 23].

However, reconstructive interventions are considered inappropriate for hip dislocation in patients of older groups with severe neurologic deficit that correspond to GMFCS IV and V due to severe femoral head and acetabulum deformities associated with a subtotal loss of the articular cartilage already developed [1, 24, 25]. L. Root points out that there is a technical possibility to reduce the femur in patients of older age groups but the procedure is completely unjustified from the point of view of pain relief and recovery of passive femur mobilization capabilities [14]. Van Riet and Moens explain the lack of prospects of reconstructive interventions in children older than 10 years of age that suffer severe CP types by an absent potential of the articular ends to remodel as they severely deform in the process of the physiological growth [26].

The main problems that occur in CP patients with hip dislocation who are older than 10 years of age are severe pain, uncomfortable position for sitting, impossible passive standing position, difficulties by hygiene in the perineal region, predisposition to bedsores due to one and the same position, and difficulties by everyday activities such as changing of clothes [5, 6, 14, 27]. It seems that a severe pain due to expressed arthrosis that is difficult to relieve is the main problem in such patients. Its incidence reaches 70 to 100 % [6, 22, 27, 29]. It was noted that the appearance of pain in the hip increases spasticity in the upper limbs and worsens their functions [5]. Other orthopaedic problems that

were described are severe knee joint contractures, marked deformities of the feet, and spine deformities [30, 31, 32].

In the complex of problems present in severe CP patients who are older than 10 years of age, hip dislocation is the main cause of impairment of their quality of life and restricts their functional abilities that initially are compromised [2, 5, 33].

Therefore, the main tasks of palliative surgical treatment in such patients are:

– pain arrest or relief [27, 34, 35, 36, 37, 38, 39];

– correction of femur malposition, possible unhindered mobilization of the femur [27, 28, 34, 40, 41, 42, 43];

– and improvement of patient's nursing, including the hygiene of the perineal region [27, 28, 34, 40].

Thus, the efficiency of treatment should be judged from the points of view mentioned.

The following methods of palliative surgical treatment are available:

– hip joint arthrodesis [14, 35];

– hip replacement [14, 27, 40, 44, 45];

– proximal femur resection arthroplasty [41, 42];

– valgus osteotomy of the proximal femur in combination with femoral head resection or without it [26, 37, 39, 46].

Hip arthrodesis seems effective from the point of view of pain relief and improvement of patient's nursing but it completely excludes hip movements [14, 35]. De Morraes Barros Fucs [35] reported on a successful arthrodesis performed in 14 patients with hip dislocation in a mean age of 15.5 years. L. Root observed two cases of nonunion in the arthrodesis area out of a total of 8 cases in the age between 8 to 33 years. Cornell reported on poor long-term arthrodesis outcomes in all the patients thus treated [24].

In general, indications for hip arthrodesis are limited. Interventions are performed by unilateral involvement, in absence of spine deformities and if there is a possibility of independent ambulation supported with additional means (GMFCS I, II, III) [14, 24, 35]. In other situations, the procedure is contraindicated [27]. The majority of orthopedic surgeons believe that the preservation of femur movements is the key element of palliative treatment. From their point of view, arthrodesis is not a method of choice [26, 27, 28, 37, 39, 41, 46, 47].

Hip replacement is one of the treatment options for CP patients who have hip dislocation and experience severe pain [40]. In their review of palliative interventions for hip dislocation in CP patients, de Souza et al. [27] pointed out the average age when hip replacement is performed being 38.1 years old. Buly et al. [44] described pain relief in 94 % of patients after hip arthroplasty. However, implants were removed in 14% of them during the next 10 years due to instability. Moreover, the selection of patients in that work was incoherent both in regard to age and neurologic deficit and included patients who were able to walk independently. Root [45] presented good outcomes of hip replacement in 13 out of 15 CP patients but most of them were able to ambulate.

Gabos et al. [40] used a shoulder implant in hip palliative surgeries as an interposition material in 14 patients with severe neurologic disorders. The mean age at intervention was 17 years. At follow-ups that averaged 4 years and nine months, a negative outcome with preservation of pain and difficulties in doing perineum hygiene was observed in one patient only. However, the radiographic findings showed that the femoral component was dislocated in a third of these cases but, nevertheless, it did not exclude the interposition function of the implant components. Koffman observed poor outcomes of total hip arthroplasty in all the cases due to femoral component dislocation, preservation of pain and femur malposition, instability of components that required revision [51]. Nevertheless, hip arthroplasty finds its indications in CP adult patients that maintain or that had an earlier ability to ambulate, less spasticity grades and cognitive abilities (GMFCS II, III) [27, 48, 49].

Proximal femur resection arthroplasty that was proposed in 1978 by Castle et al. [34] remains a commonly used surgical intervention. This operation includes an extraperiosteal resection of the proximal femur lower than the smaller trochanter level. Thereby, the portions of quadriceps are sutured over the sawn diaphysis. Adductors, iliopsoas, joint capsule, gluteus minimus and medius muscles are sutured over the acetabulum thus providing the interposition of soft tissues between the femur and acetabulum.

This intervention is performed in the patients with

severe motor and cognitive disorders (GMFCS IV, V) that are not able to ambulate even with additional means of support [10, 27, 28, 41, 43]. In the following reviews of literature, de Souza indicated the age of 17.6 years as the mean age for this intervention [27], Albinana et al. [28] – the mean age of 14 years and 4 months (range: 9.5-17 years), Widmann et al. [43] – 26.6 years, Knaus et al. [41] – in the age interval from 3 to 27 years, and Abu-Rajab et al. [50] – the mean age of 16.2 years (range: 11-26 years).

All the literature sources that were studied by us report on fair outcomes of this intervention. Pain relief was observed in all the cases of the series reported by Widmann et al. [43]. Abu-Rajab et al. [50] achieved pain reduction in 90 % of cases. Knaus et al. [41] in the series of 19 patients stated that pain was absent in 8 patients at long term, pain reduced in 9 patients while pain remained at the same level of intensity in one case, and in another one it increased. And finally, Albinana et al. [28] achieved pain relief in seven cases out of 8 and reduction of pain in one patient. Conditions for performing hygienic procedures improved in 62 to 100 % of the cases in the series above mentioned [28, 41, 43, 50]. Improved conditions to acquire and maintain a sitting position, increased passive range of femur motion of different grades were observed in all the patients at long term [28, 41, 43, 50].

An important element in the postoperative period following proximal femur resection arthroplasty is soft tissue or skeletal traction or external fixation for a period of two to 6 weeks which is aimed at reduction of the proximal migration of the femur and thus at exclusion of the mechanical contact between the femur and pelvic bones [28, 34, 41]. However, the period of inpatient stay becomes longer in this case, and in the opinion of Knaus и Leet it is a negative element of this type of treatment [41, 52].

Infection, deep bed-sores, persistent pain for three to 6 months after surgery, deep venous thrombosis, loss of appetite and the necessity to give food through a gastrostromy tube, and even death on the following day after the operation are the complications of this method of surgical palliative treatment [28, 41, 52]. A specific important problem is occurrence of periosteal or heterotopic ossificates. Three types of them were distin-

guished: type I – proximal femoral end shaped as a mushroom cap, type II – spike-end periosteal ossificates; type III – diffused heterotopic ossification [53]. In type II, a reoperation may be needed for resection of sharp end periosteal layers [41].

The shortcoming of this method is a comparatively high invasiveness: hemotransfusion may be needed in 100 % of cases [28]. Knaus et al. [41] reported deaths of two patients on day 4 and 11 postoperatively due to bleeding stomach ulcers. Albinana et al. [28] also reported on a case of stomach bleeding in the early postoperative period.

An alternative method to proximal femur resection is valgus osteotomy of the proximal femur [46, 37, 39, 54]. This procedure is considered to be less invasive and without the risk of proximal migration of the femur. Moreover, it is not accompanied by formation of periosteal and heterotopic ossificates [27, 28].

The basic technique of the intervention is the McHale procedure described in 1990 [37]. The technical peculiarity of the intervention is resection of the femoral head and neck, subtrochanteric wedge osteotomy of about 45 degrees to obtain the proximal femur valgus and plunging of the smaller trochanter into the acetabulum. In order to retain the trochanter in the acetabulum, the ligamentum rotundum is sutured to the tendon of the iliopsoas muscle in the region of the smaller trochanter. Fixation of bone fragments is realized with a regular DCP plate and 6 screws according to the new shape of the proximal femur. Hip plaster cast is used for immobilization on average for 3 weeks. Careful mobilization may be started once bone callus signs appear, usually in 6 to 8 weeks post-surgery [37, 52, 54]. Soft tissue traction may be applied or position with femur in abduction for 10 days [26].

Valgus osteotomy without resection of the femoral head is a variant of this technique [39]. The authors point out that this procedure is less traumatic and is indicated for patients that are in severe somatic condition. Nevertheless, it remains as a variant of valgus support osteotomy [27].

As for the efficiency of the valgus osteotomy, the authors report on pain relief in 60 to 92.7 % of cases or its considerable reduction in the rest of the cases [26, 37, 39, 52]. Improvement of the conditions for nursing

care was stated in the studies that analyze the results of valgus osteotomy in combination with the femoral head resection [26, 37, 52]. Increased tolerance of being in a sitting position was noted in all the cases [26, 37, 52, 54]. Femur flexion of 90 degrees and more was observed not less than in 76.9 % of patients [26, 37, 52] while it was not less than 70 degrees in the remaining cases. Femur abduction of 35 degrees and more was stated in 69.2 to 100 % of cases.

High incidence of lumbar hyperlordosis was an orthopedic consequence in the patients with a preserved femoral head [39].

Other complications of proximal femoral valgus osteotomy were described and are:

– Preservation of pain during the first two years after the operation. Thus, in the series of Riet et al. pain continued to persist in seven out of 13 cases and relieved only when the osteosynthesis plate was removed. However, the protrusion of the screw and the mechanical conflict with the acetabulum was verified only in one case [26]. In the series of Schejbalova et al. [39], pain at long-term period was relieved by performing resection in the proximal femur that was used only in the cases of valgus osteotomy without resection of the femoral head;

– Femoral fracture at the level of the distal screw and performance of proximal femur resection [26];

– Inconsiderable minimal heterotopic ossificates that were of no clinical significance [26, 37];

– Lateral migration of the femur accompanied by a mild increase of pain [26];

– Palpated plate and pain in its area that ceased after osteosynthesis material removal [37];

– Secondary displacement of bone fragments due to failed osteosynthesis [26];

– Severe pulmonary infection that resulted in the intensive care for two months and in painless fibrous ankylosis between the femur and pelvis at 90 degrees of flexion and 25 degrees of abduction [26].

There are few studies that compare the outcomes of proximal resection arthroplasty and valgus osteotomy. The authors of such studies opine that both surgical procedures have a similar efficiency in regard to pain relief, improvement of nursing care conditions and patient's greater comfort in a sitting position [52, 54].

Pain gradually subsides within two [37] to six months [43] after operations. However, at long term the degree of pain relief is higher after resection arthroplasty. Subjective satisfaction is also higher after resection arthroplasty than after valgus osteotomy. However, there is no statistical difference between these groups when compared [52].

Nevertheless, valgus osteotomy performed in combination with femoral head resection seems more preferable due to a shorter inpatient stay, lower degree of the proximal femur migration and inconsiderable formation of ossificates [52, 54]. Opinions differ in regard to the number and severity of complications. Leet et al. [52] reported on a lower incidence of surgical and general complications by McHale operation while Van Riet et al. [26] observed a high incidence of complications by using this intervention.

Other issues that remain open are differential indications for choosing either valgus osteotomy or resection arthroplasty of the proximal femur. It seems that the degree of valgisation, intervention invasiveness on tendons and muscles, plate shape and type (adapted or not to fix osteoporotic bone fragments) are also significant by performing the McHale intervention for reduction of postoperative complications and improvement of functional outcomes.

Another issue is a combination of palliative interventions on the hip with reconstructive procedures on the feet and knee joint. Orthopaedic complications such as severe foot deformities or knee joint contractures are encountered in adolescents and young adults and impair their quality of life [5, 6, 31, 38, 55]. Simultaneous palliative and reconstructive operations correspond to the principle of Single – Event Multilevel Orthopedic Surgery and foresee the use of maximum sparing surgical methods [16, 17, 19], taking in account a poor general somatic health of such patients [56, 57, 58, 59].

And finally, palliative surgical treatment should not exclude the possibility of passive vertical positioning of patients that is extremely important for heart and lung functions [60], gastrointestinal tract [61], improvement of bone mineral density and fracture prevention [61, 62].

According to the literatures that was studied, palliative interventions for hip dislocation in patients with severe CP types (GMFCS IV, V) in the age of 10 years and older remain on the agenda and are aimed at pain

relief, improvement of hygienic nursing, increase in femur movements range and better ability of patients to acquire a sitting position. However, there remains a problem of improving the technical issues of surgical treatment, clear definition of indications to each of the palliative techniques. Moreover, it is important to find the ways to perform palliative operations as a part of a multilevel approach both in view of reducing the total number of operations and improving patients' quality of life. And last, the palliative method used for hip dislocation should provide a passive standing position that is extremely important for improving the general quality of life and prevention of complications of the internal organs or fractures that happen due to low BMD levels.

REFERENCES

1. Cooke P.H., Cole W.G., Carey R.P. Dislocation of the hip in cerebral palsy. Natural history and predictability. *J. Bone Joint Surg. Br.*, 1989, vol. 71, no. 3, pp. 441-446.
2. Samilson R.L., Tsou P., Aamoth G., Green W.M. Dislocation and subluxation of the hip in cerebral palsy. Pathogenesis, natural history and management. *J. Bone Joint Surg. Am.*, 1972, vol. 54, no. 4, pp. 863-873.
3. Soo B., Howard J.J., Boyd R.N., Reid S.M., Lanigan A., Wolfe R., Reddihough D., Graham H.K. Hip displacement in cerebral palsy. *J. Bone Joint Surg. Am.*, 2006, vol. 88, no. 1, pp. 121-129.
4. Terjesen T. Development of the hip joints in unoperated children with cerebral palsy: a radiographic study of 76 patients. *Acta Orthop.*, 2006, vol. 77, no. 1, pp. 125-131.
5. Viehweger E. Importance of hip problems in daily activities for cerebral palsy patients. *J. Child. Orthop.*, 2013, vol. 7, no. 5, pp. 401-406. doi: 10.1007/s11832-013-0514-7.
6. Cooperman D.R., Bartucci E., Dietrick E., Millar E.A. Hip dislocation in spastic cerebral palsy: long-term consequences. *J. Pediatr. Orthop.*, 1987, vol. 7, no. 3, pp. 268-276.
7. Morton R.E., Scott B., McClelland V., Henry A. Dislocation of the hips in children with bilateral spastic cerebral palsy, 1985-2000. *Dev. Med. Child. Neurol.*, 2006, vol. 48, no. 7, pp. 555-558.
8. Scrutton D., Baird G., Smeeton N. Hip dysplasia in bilateral cerebral palsy: incidence and natural history in children aged 18 months to 5 years. *Dev. Med. Child. Neurol.*, 2001, vol. 43, no. 9, pp. 586-600.
9. Valencia F.G. Management of hip deformities in cerebral palsy. *Orthop. Clin. North Am.*, 2010, vol. 41, no. 4, pp. 549-559. doi: 10.1016/j.ocl.2010.07.002.
10. Ackerly S., Vitztum C., Rockley B., Olney B. Proximal femoral resection for subluxation or dislocation of the hip in spastic quadriplegia. *Dev. Med. Child. Neurol.*, 2003, vol. 45, no. 7, pp. 436-440.
11. Hägglund G., Lauge-Pedersen H., Wagner P. Characteristics of children with hip displacement in cerebral palsy. *BMC Musculoskelet. Disord.*, 2007, vol. 8, pp. 101.
12. Larnert P., Risto O., Hägglund G., Wagner P. Hip displacement in relation to age and gross motor function in children with cerebral palsy. *J. Child. Orthop.*, 2014, vol. 8, no. 2, pp. 129-134. doi: 10.1007/s11832-014-0570-7.
13. Hägglund G., Andersson S., Düppe H., Lauge-Pedersen H., Nordmark E., Westbom L. Prevention of dislocation of the hip in children with cerebral palsy. The first ten years of a population-based prevention programme. *J. Bone Joint Surg. Br.*, 2005, vol. 87, no. 1, pp. 95-101.
14. Root L. Surgical treatment for hip pain in the adult cerebral palsy patient. *Dev. Med. Child. Neurol.*, 2009, vol. 51, no. Suppl. 4, pp. 84-91. doi: 10.1111/j.1469-8749.2009.03421.x.
15. Carr C., Gage J.R. The fate of nonoperated hip in cerebral palsy. *J. Pediatr. Orthop.*, 1987, vol. 7, no. 3, pp. 262-267.
16. Popkov D.A., Zmanovskaia V.A., Gubina E.B., Leonchuk S.S., Butorina M.N., Pavlova O.L. Rezul'taty mnogourovnevykh odnomomentnykh ortopedicheskikh operatsii i rannei reabilitatsii v komplekse s botulinoterapiei u patsientov so spasticheskimi formami tserebral'nogo paralicha [Results of multilevel acute orthopedic surgeries and early rehabilitation in conjunction with botulinotherapy in patients with spastic forms of cerebral palsy]. *Zhurn. nevrologii i psikhiatrii im. C.C. Korsakova*, 2015, vol. 115, no. 4, pp. 41-48. (In Russ.)
17. McGinley J.L., Dobson F., Ganeshalingam R., Shore B.J., Rutz E., Graham H.K. Single-event multilevel surgery for children with cerebral palsy: a systematic review. *Dev. Med. Child. Neurol.*, 2012, vol. 54, no. 2, pp. 117-128. doi: 10.1111/j.1469-8749.2011.04143.x.
18. Miller F., Cardoso Dias R., Dabney K.W., Lipton G.E., Triana M. Soft-tissue release for spastic hip subluxation in cerebral palsy. *J. Pediatr. Orthop.*, 1997, vol. 17, no. 5, pp. 571-584.
19. McNerney N.P., Mubarak S.J., Wenger D.S. One-stage correction of the dysplastic hip in cerebral palsy with the San Diego acetabuloplasty: results and complications in 104 hips. *J. Pediatr. Orthop.*, 2000, vol. 20, no. 1, pp. 93-103.
20. Popkov D., Journeau P., Popkov A. Comparative study on results of reconstructive surgery in 45 hip joints of 25 children with cerebral palsy. *Eur. Orthop. Traumatol.*, 2014, vol. 5, no. 1, pp. 57-63.
21. Mubarak S.J., Valencia F.G., Wenger D.R. One-stage correction of the spastic dislocated hip. Use of pericapsular acetabuloplasty to improve coverage. *J. Bone Joint Surg. Am.*, 1992, vol. 74, no. 9, pp. 1347-1357.
22. Root L., Laplaza F.J., Brourman S.N., Angel D.H. The severely unstable hip in cerebral palsy. Treatment with open reduction, pelvic osteotomy, and femoral osteotomy with shortening. *J. Bone Joint Surg. Am.*, 1995, vol. 77, no. 5, pp. 703-712.

23. Song H.R., Carroll N.C. Femoral varus derotation osteotomy with or without acetabuloplasty for unstable hips in cerebral palsy. *J. Pediatr. Orthop.*, 1998, vol. 18, no. 1, pp. 62-68.

24. Cornell M.S. The hip in cerebral palsy. *Dev. Med. Child. Neurol.*, 1995, vol. 37, no. 1, pp. 3-18.

25. Pountney T., Green E.M. Hip dislocation in cerebral palsy. *BMJ*, 2006, vol. 332, no. 7544, pp. 772-775.

26. Van Riet A., Moens P. The McHale procedure in the treatment of the painful chronically dislocated hip in adolescents and adults with cerebral palsy. *Acta Orthop. Belg.*, 2009, vol. 75, no. 2, pp. 181-188.

27. De Souza R.C., Mansano M.V., Bovo M., Yamada H.H., Rancan D.R., Fucs P.M., Svartman C., De Assumpção R.M. Hip salvage surgery in cerebral palsy cases: a systematic review. *Rev. Bras. Ortop.*, 2015, vol. 50, no. 3, pp. 254-259. doi: 10.1016/j.rboe.2015.06.003.

28. Albiñana J., Gonzalez-Moran G. Painful spastic hip dislocation: proximal femoral resection. *Iowa Orthop. J.*, 2002, vol. 22, pp. 61-65.

29. Jóźwiak M., Walczak M., Idzior M. Appearance of spastic hip pain in cerebral palsy children. *Chir. Narzadow Ruchu Ortop. Pol.*, 2005, vol. 70, no. 2, pp. 101-104.

30. Fulford G.E. Surgical management of ankle and foot deformities in cerebral palsy. *Clin. Orthop. Relat. Res.*, 1990, no. 253, pp. 55-61.

31. Horstmann H.M., Hosalkar H., Keenan M.A. Orthopaedic issues in the musculoskeletal care of adults with cerebral palsy. *Dev. Med. Child. Neurol.*, 2009, vol. 51, no. Suppl. 4, pp. 99-105. doi: 10.1111/j.1469-8749.2009.03417.x.

32. Kołodziej Ł., Dobiecki K., Sadlik B. Surgical treatment of advanced, stiff neurologic cavovarus foot in adults. *Ortop. Traumatol. Rehabil.*, 2013, vol. 15, no. 4, pp. 325-333. doi: 10.5604/15093492.1073831.

33. Knapp D.R. Jr., Cortes H. Untreated hip dislocation in cerebral palsy. *J. Pediatr. Orthop.*, 2002, vol. 22, no. 5, pp. 668-671.

34. Castle M.E., Schneider C. Proximal femoral resection-interposition arthroplasty. *J. Bone Joint Surg. Am.*, 1978, vol. 60, no. 8, pp. 1051-1054.

35. De Moraes Barros Fucs P.M., Svartman C., De Assumpção R.M., Kertzman P.F. Treatment of the painful chronically dislocated and subluxated hip in cerebral palsy with hip arthrodesis. *J. Pediatr. Orthop.*, 2003, vol. 23, no. 4, pp. 529-534.

36. Hodgkinson I., Jindrich M.L., Duhaut P., Vadot J.P., Metton G., Bérard C. Hip pain in 234 non-ambulatory adolescents and young adults with cerebral palsy: a cross-sectional multicentre study. *Dev. Med. Child. Neurol.*, 2001, vol. 43, no. 12, pp. 806-808.

37. McHale K.A., Bagg M., Nason S.S. Treatment of the chronically dislocated hip in adolescents with cerebral palsy with femoral head resection and subtrochanteric valgus osteotomy. *J. Pediatr. Orthop.*, 1990, vol. 10, no. 4, pp. 504-509.

38. Noonan K.J., Jones J., Pierson J., Honkamp N.J., Leverson G. Hip function in adults with severe cerebral palsy. *J. Bone Joint Surg. Am.*, 2004, vol. 86-A, no. 12, pp. 2607-2613.

39. Schejbalova A., Havlas V., Trc T. Irreducible dislocation of the hip in cerebral palsy patients treated by Schanz proximal femoral valgus osteotomy. *Int. Orthop.*, 2009, vol. 33, no. 6, pp. 1713-1717. doi: 10.1007/s00264-008-0676-y.

40. Gabos P.G., Miller F., Galban M.A., Gupta G.G., Dabney K. Prosthetic interposition arthroplasty for the palliative treatment of end-stage spastic hip disease in nonambulatory patients with cerebral palsy. *J. Pediatr. Orthop.*, 1999, vol. 19, no. 6, pp. 796-804.

41. Knaus A., Terjesen T. Proximal femoral resection arthroplasty for patients with cerebral palsy and dislocated hips: 20 patients followed for 1-6 years. *Acta Orthop.*, 2009, vol. 80, no. 1, pp. 32-36. doi: 10.1080/17453670902804935.

42. Muthusamy K., Chu H.Y., Friesen R.M., Chou P.C., Eilert R.E., Chang F.M. Femoral head resection as a salvage procedure for the severely dysplastic hip in nonambulatory children with cerebral palsy. *J. Pediatr. Orthop.*, 2008, vol. 28, no. 8, pp. 884-889. doi: 10.1097/BPO.0b013e31818e8569.

43. Widmann R.F., Do T.T., Doyle S.M., Burke S.W., Root L. Resection arthroplasty of the hip for patients with cerebral palsy: an outcome study. *J. Pediatr. Orthop.*, 1999, vol. 19, no. 6, pp. 805-810.

44. Buly R.L., Huo M., Root L., Binzer T., Wilson P.D. Jr. Total hip arthroplasty in cerebral palsy. Long-term follow-up results. *Clin. Orthop. Relat. Res.*, 1993, no. 296, pp. 148-153.

45. Root L., Goss J.R., Mendes J. The treatment of the painful hip in cerebral palsy by total hip replacement or hip arthrodesis. *J. Bone Joint Surg. Am.*, 1986, vol. 68, no. 4, pp. 590-598.

46. Agashe M., Song S.H., Tong X.B., Hong J.H., Song H.R. Subtrochanteric valgus osteotomy with monolateral external fixator in hips for patients with severe cerebral palsy. *Orthopedics*, 2013, vol. 36, no. 2, pp. e139-e146. doi: 10.3928/01477447-20130122-13.

47. *Sposob lecheniia vyvikha bedra u detei i podrostkov s paralichami* [A techniqiue for hip dislocation treatment in children and adolescents with palsies]. Pat. RF, no. 2008145879/14, 2010. (In Russ.)

48. Raphael B.S., Dines J.S., Akerman M., Root L. Long-term followup of total hip arthroplasty in patients with cerebral palsy. *Clin. Orthop. Relat. Res.*, 2010, vol. 468, no. 7, pp. 1845-1854. doi: 10.1007/s11999-009-1167-1.

49. Schroeder K., Hauck C., Wiedenhöfer B., Braatz F., Aldinger P.R. Long-term results of hip arthroplasty in ambulatory patients with cerebral palsy. *Int. Orthop.*, 2010, vol. 34, no. 3, pp. 335-339. doi: 10.1007/s00264-009-0771-8.

50. Abu-Rajab R.B., Bennet G.C. Proximal femoral resection-interposition arthroplasty in cerebral palsy. *J. Pediatr. Orthop. B*, 2007, vol. 16, no. 3, pp. 181-184.

51. Koffman M. Proximal femoral resection or total hip replacement in severely disabled cerebral-spastic patients. *Orthop. Clin. North Am.*, 1981, vol. 12, no. 1, P. 91-100.

52. Leet A.I., Chhor K., Launay F., Kier-York J., Sponseller P.D. Femoral head resection for painful hip subluxation in cerebral pal-

Literature review

sy: Is valgus osteotomy in conjunction with femoral head resection preferable to proximal femoral head resection and traction? *J. Pediatr. Orthop.*, 2005, vol. 25, no. 1, pp. 70-73.

53. McCarthy R.E., Simon S., Douglas B., Zawacki R., Reese N. Proximal femoral resection to allow adults who have severe cerebral palsy to sit. *J. Bone Joint Surg. Am.*, 1988, vol. 70, no. 7, pp. 1011-1016.

54. Wright P.B., Ruder J., Birnbaum M.A., Phillips J.H., Herrera-Soto J.A., Knapp D.R. Outcomes after salvage procedures for the painful dislocated hip in cerebral palsy. *J. Pediatr. Orthop.*, 2013, vol. 33, no. 5, pp. 505-510. doi: 10.1097/BPO.0b013e3182924677.

55. Krebs A., Strobl W.M., Grill F. Neurogenic hip dislocation in cerebral palsy: quality of life and results after hip reconstruction. *J. Child. Orthop.*, 2008, vol. 2, no. 2, pp. 125-131. doi: 10.1007/s11832-008-0080-6.

56. Brooks J., Day S., Shavelle R., Strauss D. Low weight, morbidity, and mortality in children with cerebral palsy: new clinical growth charts. *Pediatrics*, 2011, vol. 128, no. 2, pp. e299-e307. doi: 10.1542/peds.2010-2801.

57. Campanozzi A., Capano G., Miele E., Romano A., Scuccimarra G., Del Giudice E., Strisciuglio C., Militerni R., Staiano A. Impact of malnutrition on gastrointestinal disorders and gross motor abilities in children with cerebral palsy. *Brain. Dev.*, 2007, vol. 29, no. 1, pp. 25-29.

58. Ozturk M., Oktem F., Kisioglu N., Demirci M., Altuntas I., Kutluhan S., Dogan M. Bladder and bowel control in children with cerebral palsy: case-control study. *Croat. Med. J.*, 2006, vol. 47, no. 2, pp. 264-270.

59. Wang H.Y., Chen C.C., Hsiao S.F. Relationships between respiratory muscle strength and daily living function in children with cerebral palsy. *Res. Dev. Disabil.*, 2012, vol. 33, no. 4, pp. 1176-1182. doi: 10.1016/j.ridd.2012.02.004.

60. Glickman L.B., Geigle P.R., Paleg G.S. A systematic review of supported standing programs. *J. Pediatr. Rehabil. Med.*, 2010, vol. 3, no. 3, pp. 197-213. doi: 10.3233/PRM-2010-0129.

61. Paleg G., Livingstone R. Outcomes of gait trainer use in home and school settings for children with motor impairments: a systematic review. *Clin. Rehabil.*, 2015, vol. 29, no. 11, pp. 1077-1091. doi: 10.1177/0269215514565947.

62. Uddenfeldt Wort U., Nordmark E., Wagner P., Düppe H., Westbom L. Fractures in children with cerebral palsy: a total population study. *Dev. Med. Child. Neurol.*, 2013, vol. 55, no. 9, pp. 821-826. doi: 10.1111/dmcn.12178.

63. Valenciano I., Dopazo J.A., Albiñana J., Martinez I. Osteotomías de cadera en la parálisis cerebral [Hip osteotomy in cerebral palsy]. *Rev. Esp. Cir. Ortop. Traumatol.*, 2001, vol. 45, no. 1, pp. 40-45.

Information about the authors:

1. Ramil' R. Bidiamshin, M.D., FSBI *RISC "RTO"* of the RF Ministry of Health, Kurgan
2. Dmitrii A. Popkov, M.D., Ph.D., FSBI *RISC "RTO"* of the RF Ministry of Health, Kurgan, Head of the Clinic of Neuroorthopaedics; e-mail: dpopkov@mail.ru