Literature review

DOI 10.18019/1028-4427-2018-24-1-95-101

Treatment of acetabular injuries and the consequences (review of literature)

O.K. Chegurov, I.N. Menshchikov

Russian Ilizarov Scientific Center for Restorative Traumatology and Orthopaedics, Kurgan, Russia

Acetabular fractures are often complex injuries and the result of high-energy trauma increasing in recent years with the increased use of high-speed motor vehicles. Acetabular fractures account for 7 to 25 % of all pelvic injuries and are associated with significant morbidity. The complex nature of these fractures requires multi-staged treatment with the usage of various methods of osteosynthesis, their combination including primary reconstructive joint replacement. In spite of the improved techniques and new technologies rehabilitation of the patients is a particularly challenging problem. **Material and methods** Literature searches were performed on several databases: PubMed, Scopus, eLibrary.ru and others. Search keywords included "acetabular injury", "consequences of acetabular fracture", "acetabular osteosynthesis", "total hip replacement", "nonunion of acetabulum", "hip arthroplasty in patients with consequences of acetabular injury". **Objective** To do analytical review on the subject "Treatment of consequences of acetabular injuries". **Conclusion** Types of acetabular injuries and methods of treatment are described in the available literature. Nevertheless, the findings showed no systemic approach to rehabilitation of the patients and there is a need to improve the existing practice and devise new techniques and algorithms of treatment

Keywords: hip joint, acetabulum, injury, consequences of acetabular fracture, osteosynthesis of acetabulum, total hip replacement

Acetabular fractures are most frequently associated with high energy trauma such as that seen in a motor vehicle accident or a fall from a height and account for 7 to 25 % of all pelvic injuries according to different authors [1, 2]. Acetabular fractures are becoming an increasingly common orthopaedic injury in recent years with the increased use of high-speed motor vehicles [3]. Motor vehicle crashes are the most common cause of acetabular fracture with a reported incidence of 40 and 76 % [4–6]. The incidence of acetabular fractures resulting from a fall from a height is 11 % [7]. Fractures of the acetabulum are mostly seen in individuals of active working age, primarily in males, that indicate to socioeconomic importance of the issue [8, 9]. Injuries of the acetabulum and the sequelae have a negative impact on the quality of life and often result in disability [10–12]. In many different ways the condition impacts the ability to do work-related activities in 50 to 70 % of the cases, and the physical disability qualifies 12 to 15 % of the patients for social security benefits [13]. Shlykov I.L. et al. (2011) and Boraiah S et al. (2009) report 65 to 80 % rate of poor outcome in pelvic injuries that result in high mortality rate, residual deformities and disability [14, 15]. There is an increasing proportion of acetabular fractures sustained as a result of polytrauma accompanied by traumatic shock [16].

Various schemes based on anatomical, clinical and radiological principles have been suggested to classify acetabular fractures [17], the Judet-Letournel classification system (AO) [18] remains the most widely accepted and classifies as elementary and associated fracture patterns and localisation of injury. Classification proposed by M. Tile allows us to look at the potential areas of pelvic ring disruptions and instability [19]. Classifications suggested by AAOS, Paprosky, Saleh give detailed information about defects of the acetabulum [20–22], the dimensions and localisation. Paprosky classification is often used for rehabilitation of orthopaedic patients evaluating the extent of bone loss that is important for surgical strategy. The variety of existing classifications of acetabular injuries provides a differentiated approach to diagnosis and the choice of treatment tactics that would sup-

Chegurov O.K., Menshchikov I.N. Treatment of acetabular injuries and the consequences (review of literature). *Genij Ortopedii*. 2018. T. 24. No 1. pp. 95-101. DOI 10.18019/1028-4427-2018-24-1-95-101. (In Russian)

posedly lead to positive outcome. However, no most common referenced classification system for sequelae of acetabular fractures could be found in the literature reviewed.

Although accurate characterisation of acetabular fractures can be difficult because of the complex acetabular anatomy radiographic examination, CT and MRI provide essential information for acetabular classification [23–25].

Considering the course of reparative process sequelae of acetabular fractures can be grouped into maluniting and malunited fractures of the acetabulum. Nonunion is a major complication that can lead to disability in some cases [26, 27]. There are no statistical data available to estimate acetabular nonunion incidence. There is evidence of increasing number of the patients that is associated with high levels of anesthesiological procedures and intensive care [28]. The overall aim of early posttraumatic period is to rapidly assess and treat life-threatening conditions [11, 29]. Pelvic fracture stabilisation is a part of antishock therapy that can be achieved either conservatively or surgically using transosseous osteosynthesis. However, the methods are inefficient for accurate anatomical reduction of acetabular injuries, fracture-dislocation of the acetabulum and old injuries [28, 30]. Imperfect reduction resulting in incongruency of more than 1 to 2 mm and persisting subluxation is evaluated as a poor outcome [31–34]. Malunited fractures can lead to degenerative changes, expressed pain and poor functional result due to impaired biomechanics in the hip joint. Patients with malunited injury can develop posttraumatic neuropathy sciatic nerve [35].

Disturbed flows in the arterial and venous systems of the involved segment can cause oxygen deficiency and impaired regeneration. Medical treatment untimely performed, poor result of reduction and fixation are iatrogenic factors contributing to nonunion. Nonunion typically occur in displaced fracture and dislocated femoral head [36, 37]. Osteosynthesis with plates and screws is applied for bone reduction and fixation in patients with disturbed fracture healing, and osteotomy can be indicated for realignment in some cases. Autografts are used to repair bone defects. Less invasive osteosynthesis can be performed for patients without neuropathy of sciatic nerve, signs of posterior instability of the femoral head and intraarticular fragments with the possibility of bringing the bone into direct contact. Total hip replacement can be an option in patients with previously failed procedures [38].

Musculoskeletal injury can induce reparative processes being manifested in heterotopic ossification in the pelvic soft tissues seen in 25.6 % of the cases [39]. Elfimova S.V. et al. (2010) identified a higher risk of heterotopic ossification observed in combination of such factors as male gender and posttraumatic coxarthritis, injury to the hip joint followed by posttraumatic coxarthritis, with the reported rate of 34 % and 33.3 %, correspondingly [40]. Heterotopic ossifications can be caused by traumatic operative interventions including THR and coxarthritis at the time of injury [41, 42]. Common presenting symptoms of heterotopic ossification are pain and limited joint movement including ankylosis [43, 44]. Commonly used prophylactic modalities include non-steroidal anti-inflammatory drugs, radiation and combination therapy [45–47].

Clinically evident progressive degeneration [32] is observed in 57 to 88 % of the cases [39] at long-term follow-up in spite of adequate treatment performed. The process is influenced by several factors including specific trauma agent and medical care rendered.

Failure to produce accurate reduction and reliable fixation within the first week of acetabular fracture is an adverse prognostic factor that entails technical difficulties for the next procedure and aggravates a surgical injury [35, 48]. A fracture of more than 21 day of injury is categorised as delayed. Anatomical bone reduction is either difficult or impossible in the cases [49]. Delayed management of acetabular fractures increases the difficulty of operative treatment and may result in a significant reduction in good outcomes [37].

Displaced acetabular fracture with a bone defect of the acetabulum is a key reason to degenerative changes. Acetabular bone loss is likely to result in femur dislocation, bone areas of lower density being sheared off at contact sites due to disturbed congruency of articular surfaces [50, 51].

Acetabular fractures are accompanied by dislocated femoral head in 15 to 80 % of the cases [52, 53]. The femoral head is at high risk of developing

aseptic necrosis of no reduction is produced within 6 to 12 hours of injury due to disturbed trophics of all articular and periarticular components [54, 55]. The pathological process with degenerative changes is caused by vascular disorders resulted from injury and continuous absence of normal loading. There is a relationship established between an extent of functional and structural changes and regional circulation [56]. Disturbed circulation as the major reason of avascular necrosis of the femoral head is identified in 10 % of the cases [39, 57]. Avascular necrosis of the femoral head leads to progressive degenerative joint disease and a higher reported incidence of musculoskeletal disability [58, 59]. Joint preserving surgeries include different osteotomies, vascularised and non-vascularised grafts, femoral head core decompression but the outcomes with the procedures are not always rewarding [60]. Arthroplasty is the method of choice when results with established surgical procedures are inconsistent and disappointing [61].

The biggest long-term complication of acetabular fracture is the development of coxarthritis seen in 20 % of the cases [39]. The most common symptoms of hip osteoarthritis are hip pain, decreased range of motion, supportability of lower limb and disturbed functioning of the whole locomotor system. If conservative treatments do not succeed following fracture reduction and fixation and hip pain seriously impinges on lifestyle primary total hip replacement may provide relief [62]. Earlier osteosynthesis of the acetabulum creates good conditions for femoral component implantation [4, 63], however, significant anatomical distortion and adhesions from previous surgeries may pose the challenge to the surgeon [64]. There is a greater uncertainty with surgical result in the cases as compared to arthroplasty performed for non-traumatic condition [5, 65]. Management of acetabular bone loss at the time of the surgery is a challenge facing orthopedic surgeons [66]. Stable fixation in smaller areas of bone deficiency can be achieved either by using greater diameter of the cup and screws or more superior placement. The bone chips obtained with acetabular treatment can be used for bone autologous graft [67, 68]. Larger areas of bone loss can be filled with bone graft harvested from the femur. Trabecular metal implant can be successfully used for better osteoinduction [67]. Antiprotrusion devices supporting lateral acetabulum can be applied in larger bone defects. Seven-to-ten follow-ups show 80 to 90 % of good outcomes [69].

Therefore, reconstructive hip arthroplasty can provide supportability of the limb, sufficient range of motion in the hip joint and pain relief.

CONCLUSION

Our review of literature suggests that sequelae of acetabular fractures are quite challenging injuries for the orthopedic surgeon. Multiple factors influence the occurrence and severity of the conditions. A variety of techniques offered to repair fractures of the acetabulum include conservative, joint preserving surgeries and total hip arthroplasty. Nevertheless, the findings indicates to the absence of systemic approach to rehabilitation of the patients, and the treatments are primarily syndrome-based. It can also be explained by the absence of integrated classification specifying sequelae of acetabular injuries. There are no statistical data on a number of consequences of acetabular fractures. Therefore, accumulation, processing and classification of statistical evidence can be helpful in developing systemic and comprehensive approach to the problem.

REFERENCES

1. Bulibina T.I., Landa V.A. O diagnostike perelomov vertluzhnoi vpadiny i nekotorykh regionarnykh gemodinamicheskikh narusheniiakh [Diagnosis of acetabular fractures and some regional hemodynamic disorders]. *Ul'trazvukovaia i Funktsional'naia Diagnostika*, 2006, no. 2, pp. 120-126. (In Russ.)
2. Grin' A.A., Runkov A.V., Shlykov I.L. Vybor operatsionnogo dostupa pri lechenii dvukhkolonnykh perelomov vertluzhnoi vpadiny [Selection of surgical approach for treatment of two-columned acetabular fractures]. *Travmatologiia i Ortopediia Rossii*, 2014, no. 1 (71), pp. 92-97. (In Russ.)
3. Borovkov V.N., Semenova V.G., Khrupalov A.A., Sorokin G.V., Borovkov N.V. Dorozhno-transportnyi travmatizm kak kompleksnaia mediko-sotsial'naia problema poter' zdorov'ia naseleniia Rossii [Traffic traumatism as

a complex medicosocial problem of the loss of the Russia population health]. *Travmatologiia i Ortopediia Rossii*, 2011, no. 3 (61), pp. 101-108. (In Russ.)
4. Kazantsev A.B., Ter-Grigorian A.A., Makarova S.I., Balitskaia N.V. Sovremennyi podkhod k endoprotezirovaniiu posle perelomov vertluzhnoi vpadiny [Modern approach to arthroplasty after acetabular fractures]. *Med. Vestnik MVD*, 2012, no. 4(59), pp.16-18. (In Russ.)
5. Laird A., Keatig J.E. Acetabular fractures: a 16-year prospective epidemiological study. *J. Bone Joint Surg. Br*., 2005, vol. 87, no. 7, pp. 969-973. DOI: 10.1302/0301-620X.87B7.16017.
6. Madhu R., Kotnis R., Al-Mousawi A., Barlow N., Deo S., Worlock P., Willett K. Outcome of surgery for reconstruction of fractures of the acetabulum – the time dependent effect of delay. *J. Bone Joint Surg. Br*., 2006, vol. 88, no. 9, pp. 1197-1203. DOI: 10.1302/0301-620X.88B9.17588.
7. Smirnov A.A., Pavlov D.V., Varvarin O.P. Khirurgicheskaia taktika pri perelomakh vertluzhnoi vpadiny [Surgical tactic for acetabular fractures]. *Travmatologiia i Ortopediia Rossii*, 2009, no. 4 (54), pp. 84-87. (In Russ.)
8. Miliukov A.Iu., Konev S.V. Kompleksnaia diagnostika povrezhdenii vertluzhnoi vpadiny u patsientov pri politravme [Complex diagnosis of acetabular injuries in patients for polytrauma]. *Politravma*, 2012, no. 3, pp. 64-67. (In Russ.)
9. Agadzhanian V.V., Pronskikh A.A., Ust'iantseva I.M., Agalarian A.Kh., Kravtsov C.A., Krylov Iu.M., Makshanova G.P., Mendelenko M.M., Miliukov A.Iu., Mikhailov V.P., Novokshonov A.V., Protopopov V.V., Rodionov E.P., Sytin L.V., Sumin A.N., Fedorov Iu.S. *Politravma* [Polytrauma]. Novosibirsk, Nauka, 2003, 492 p. (In Russ.)
10. Lazarev A.F., Solod E.I., Gudushauri Ia.G., Kakabadze M.G., Sakharnykh I.N., Stoiukhin S.S. Osobennosti lecheniia perelomov vertluzhnoi vpadiny [Features of treating acetabular feactures]. *Sovremennoe Iskusstvo Meditsiny*, 2013, no. 4 (12), pp. 58-64. (In Russ.)
11. Bondarenko A.V., Kruglykhin I.V., Plotnikov I.A., Voitenko A.N., Zhmurkov O.A. Osobennosti lecheniia povrezhdenii taza pri politravme [Freatures of treating pelvic injuries for polytauma]. *Politravma*, 2014, no. 3, pp. 46-57. (In Russ.)
12. Azizov M.Zh., Ruziboev D.R. Kliniko-funktsional'nye rezul'taty total'nogo endoprotezirovaniia tazobedrennogo sustava [Clinical-functional results of total arthroplasty of the hip]. *Ortopediia, Travmatologiia i Protezirovanie*, 2012, no. 1, pp. 81-83. (In Russ.)
13. Khudobin V.Iu. Iskhody lecheniia vnutrisustavnykh povrezhdenii vertluzhnoi vpadiny [Outcomes of treating intraarticular acetabular injuries]. *Ortopediia, Travmatologiia i Protezirovanie*, 2012, no. 3, pp. 20-26. (In Russ.)
14. Shlykov I.L., Kuznetsova N.L. Lechebnye algoritmy u patsientov s travmoi taza i vertluzhnoi vpadiny [Medical algorithms in patients with pelvic and acetabular injury]. *Biulleten' VSNTs CO RAMN*, 2011, no. 4(80), pp. 339-343. (In Russ.)
15. Boraiah S., Ragsdale M., Achor T., Zelicof S., Asprinio D.E. Open reduction internal fixation and primary total hip arthroplasty of selected acetabular fractures. *J. Orthop. Trauma*, 2009, vol. 23, no. 4, pp. 243-248. DOI: 10.1097/BOT.0b013e3181923fb8.
16. Bagnenko S.F., Stozharov V.V., Miroshnichenko A.G., Vishniakov N.I. eds. *Dorozhno-transportnyi travmatizm kak mediko-sotsial'naia problema* [Traffic traumatism as a medical-social problem]. SPb., IPK «KOSTA», 2006, pp. 86-121. (In Russ.)
17. Miliukov A.Iu. Klassifikatsiia povrezhdenii vertluzhnoi vpadiny [Classification of acetabular ijuries]. *Meditsina i Obrazovanie v Sibiri*, 2012, no. 2, pp. 53-54. (In Russ.)
18. Judet R., Judet J., Letournel E. Fractures of the acetabulum: classification and surgical approaches for open reduction. Preliminary report. *J. Bone Joint Surg. Am*., 1964, vol. 46, pp. 1615-1646.
19. Tile M., Helfet D.L., Kellam J.F. *Fractures of the pelvis and acetabulum.* 3rd ed. Philadelphia: Lippinkott, Williams and Wilkins, 2003, 830 p.
20. Paprosky W.G., Perona P.G., Lawrence J.M. Acetabular defect classification and surgical reconstruction in revision arthroplasty. A 6-year follow-up evaluation. *J. Arthroplasty*, 1994, vol. 9, no. 1, pp. 33-44.
21. D'Antonio J.A., Capello W.N., Borden L.S., Bargar W.L., Bierbaum B.F., Boettcher W.G., Steinberg M.E., Stulberg S.D., Wedge J.H. Classification and management of acetabular abnormalities in total hip arthroplasty. *Clin. Orthop. Relat. Res*., 1989, no. 243, pp. 126-137.
22. Saleh K.J., Holtzman J., Gafni ASaleh L., Jaroszynski G., Wong P., Woodgate I., Davis A., Gross A.E. Development, test reliability and validation of a classification for revision hip arthroplasty. *J. Orthop. Res*., 2001, vol. 19, no. 1, pp. 50-56. DOI: 10.1016/S0736-0266(00)00021-8.
23. Grin' A.A., Sergeev K.S., Bazarov A.Iu., Shaternikov B.N. Nash opyt lecheniia povrezhdenii taza apparatami vneshnei fiksatsii [Our experience of treating pelvic injuries with external fixators]. *Sbornik tezisov II Moskovskogo Mezhdunarodnogo kongressa travmatologov i ortopedov "Povrezhdeniia pri dorozhno-transportnykh proisshestviiakh i ikh posledstviia: nereshennye voprosy, oshibki i oslozhneniia"* [Proc. II Moscow International Congress of traumatologists and orthopedists "Injuries for traffic accidents and their consequences: unresolved problems,

errors and complications"]. Moscow, 2011, p. 192. (In Russ.)
24. Briffa N., Pearce R., Hill A.M., Bircher M.J. Outcomes of acetabular fracture fixation with ten years' follow-up. *J. Bone Joint Surg. Br*., 2011, vol. 93, no. 2, pp. 229-236. DOI: 10.1302/0301-620X.93B2.24056.
25. Reagan J.M., Moed B.R. Can computed tomography predict hip stability in posterior wall acetabular fractures? *Clin. Orthop. Relat. Res*., 2011, vol. 469, no. 7, pp. 2035-2041. DOI: 10.1007/s11999-011-1790-5.
26. Leonova S.N., Rekhov A.V., Shigaev E.S. Mineral'naia plotnost' kostnoi tkani – integral'nyi pokazatel' sostoianiia protsessa regeneratsii [Mineral density of bone tissue – integral value of regeneration process state]. *Tezisy dokl. VII s"ezda travmatologov-ortopedov Rossii* [Proc. VII Congress of traumatologists-orthopedists of Russia]. Novosibirsk, 2002, p. 334. (In Russ.)
27. Bauer I.V., Kazarezov M.V., Velichko A.Ia., Koroleva A.M., Rybalko I.V., Zhilenko V.Iu., Granitsa D.O. Povyshenie effektivnosti reabilitatsii invalidov s psevdoartrozami pri vybore obosnovannogo operativnogo standarta v zavisimosti ot vida nesrashcheniia [Improving the effrectiveness of rehabilitation of disabled persons with pseudoarthroses when selected the reasonable surgical standard depending on non-union type]. *Meditsina i Obrazovanie v Sibiri*, 2010, no. 5, p. 9. (In Russ.)
28. Kazantsev A.B., Ter-Grigorian A.A., Putiatin S.M., Makarova S.I. Operativnye dostupy pri perelomakh kostei taza [Surgical approaches for fractures of pelvic bones]. *Vestn. Eksperimental'noi i Klinicheskoi Khirurgii*, 2011, no. 2 (4), pp. 305-313. (In Russ.)
29. Valiyev E.Iu., Tiliakov A.B., Madaliyev B.R., Karimov B.R. Sovershenstvovanie lechebno-diagnosticheskikh aspektov povrezhdenii vertluzhnoi vpadiny [The perfection of the treatment-and-diagnosis aspects of acetabular injuries]. *Genij Ortopedii*, 2005, no. 3, pp. 20-14. (In Russ.)
30. Cherkes-Zade D.I. *Povrezhdeniia taza* [Pelvic injuries]. In: Shaposhnikov Iu.G., ed. Ruk. dlia vrachei [Guide for physicians]. M., Meditsina, 1997, 249 p. (In Russ.)
31. Riudi T.P., Bakli R.E., Moran K.G. AO – printsipy lecheniia perelomov: 2100 risunkov, rentgenogramm, modelei i khirurgicheskikh skhem: v 2-kh t. [AO-principles of fracture treatment: 2100 figures, X-rays, models and surgical schemes: in 2 Vol.]. Per. s angl. A.A. Sitnik [Transl. from English A.A. Sitnik]. Leipzig, 2013, vol. 2, 721 p. (In Russ.)
32. Giannoudis P.V., Grotz M.R., Papakostidis C., Dinopoulos H. Operative treatment of displaced fractures of the acetabulum. A meta-analysis. *J. Bone Joint Surg. Br*., 2005, vol. 87, no. 1, pp. 2-9.
33. Hak D.J., Hamel A.J., Bay B.K., Sharkey N.A., Olson S.A. Consequences of transverse acetabular fracture malreduction on load transmission across the hip joint. *J. Orthop. Trauma*, 1998, vol. 12, no. 2, pp. 90-100.
34. Tornetta P. 3rd. Non-operative management of acetabular fractures: The use of dynamic stress views. *J. Bone Joint Surg. Br*., 1999, vol. 81, no. 1, pp. 67-70.
35. Buachidze O.Sh., Onoprienko G.A., Voloshin V.P., Zubikov V.S. *Khirurgiia tazobedrennogo sustava* [Surgery of the hip]. M., Meditsina, 2002, 136 p. (In Russ.)
36. Letournel E., Judet R. *Fractures of the Acetabulum*. 2nd ed. Elson R.A., ed. Berlin, Heidelberg, Springer-Verlag, 1993, 733 p.
37. Johnson E.E., Matta J.M., Mast J.W., Letournel E. Delayed reconstruction of acetabular fractures 21-120 days following injury. *Clin. Orthop. Relat. Res*., 1994, no. 305, pp. 20-30.
38. Smith W.R., Ziran B.H., Morgan S.J., eds. *Fractures of the Pelvis and Acetabulum.* New York, Informa Healthcare Inc., 2007.
39. Tikhilov R.M., Shubniakov I.I., Chiladze I.T., Pliev D.G., Shorustamov M.T., Artiukh V.A., Ambrosenkov A.V., Blizniukov V.V., Miasoedov A.A. Vybor sposoba implantatsii vertluzhnogo komponenta na osnove na rabochei klassifikatsii posledstvii perelomov vertluzhnoi vpadiny [Choosing a way of acetabular component implantation based on the working classification of consequences of acetabular fractures]. *Travmatologiia i Ortopediia Rossii*, 2011, no. 2 (60), pp. 37-43. (In Russ.)
40. Elfimov S.V., Kuznetsova N.L. Kliniko-anamnesticheskie kriterii prognoza razvitiia geterotopicheskoi ossifikatsii posle operatsii na tazobedrennom sustave [Clinical-anamnestic criteria of the prediction of heterotopic ossification development after surgery of the hip]. *Vestn. Travmatologii i Ortopedii Urala*, 2010, no. 3, pp. 17-20. (In Russ.)
41. Cadosch D., Bauer S., Gautschi O.P., Filgueira L., Zellweger R. Surgical arthrolysis in patients with high-grade heterotopic ossification after hip joint endoprosthesis. *Unfallchirurg*, 2008, vol. 111, no. 7, pp. 535-538. DOI: 10.1007/s00113-008-1462-4.
42. Devnani A.S. Management of heterotopic ossification affecting both hips and knees. *Singapore Med. J*., 2008, vol. 49, no. 6, pp. 501-504.
43. Kocić M., Lazović M., Kojović Z., Mitković M., Milenković S., Cirić T. Methods of the physical medicine therapy in prevention of heterotopic ossification after total hip arthroplasty. *Vojnosanit. Pregl*., 2006, vol. 63, no. 9, pp. 807-811.

44. Pakos E.E., Pitouli E.J., Tsekeris P.G., Papathanasopoulou V., Stafilas K., Xenakis T.H. Prevention of heterotopic ossification in high-risk patients with total hip arthroplasty: the experience of a combined therapeutic protocol. *Int. Orthop*., 2006, vol. 30, no. 2, pp. 79-83. DOI: 10.1007/s00264-005-0054-y.
45. Mitchell E.J., Canter J., Norris P., Jenkins J., Morris J. The genetics of heterotopic ossification: insight into the bone remodeling pathway. *J. Orthop. Trauma*, 2010, vol. 24, no. 9, pp. 530-533. DOI: 10.1097/BOT.0b013e3181ed147b.
46. Piatek S., Westphal T., Arbter D., Winckler S. Value of a combined ossification prophylaxis with indomethacin and radiotherapy for acetabular fractures. *Unfallchirurg*, 2006, vol. 109, no. 7, pp. 556-562. DOI: 10.1007/s00113-006-1083-8.
47. Karunakar M.A., Sen A., Bosse M.J., Sims S.H., Goulet J.A., Kellam J.F. Indometacin as prophylaxis for heterotopic ossification after the operative treatment of fractures of the acetabulum. *J. Bone Joint Surg. Br*., 2006, vol. 88, no. 12, pp. 1613-1617. DOI: 10.1302/0301-620X.88B12.18151.
48. Cherkes-Zade D.I. *Lechenie povrezhdenii taza i ikh posledstvii* [Treatment of pelvic injuries and their consquences]. M., Meditsina, 2006, 192 p. (In Russ.)
49. Voloshin V.P., Onoprienko G.A., Zubikov V.S. Khirurgicheskoe lechenie chrezvertluzhnykh perelomov tazovoi kosti [Surgical treatment of transacetabular pelvic bone fractures]. *Al'manakh Klin. Meditsiny*, 2008, no. 19, pp. 37-42. (In Russ.)
50. Tikhilov R.M., Shubniakov I.I. *Rukovodstvo po khirurgii tazobedrennogo sustava* [Manual of the hip surgery]. SPb., RNIITO im. R.R. Vredena, 2014, vol. 1, 368 p. (In Russ.)
51. Tikhilov R.M., Shapovalov V.A. *Rukovodstvo po endoprotezirovaniiu tazobedrennogo sustava* [Manual of the hip arthroplasty]. SPb., RNIITO im. R.R. Vredena, 2008, 324 p. (In Russ.)
52. Alexa O., Malancea R.I., Puha B., Luncă S., Veliceasa B. Results of surgical treatment of acetabular fractures using Kocher-Langenbeck approach. *Chirurgia* (Bucur), 2013, vol. 108, no. 6, pp. 879-885.
53. Bhandari M., Matta J., Ferguson T., Matthys G. Predictors of clinical and radiological outcome in patients with fractures of the acetabulum and concomitant posterior dislocation of the hip. *J. Bone Joint Surg. Br*., 2006, vol. 88, no. 12, pp. 1618-1624. DOI: 10.1302/0301-620X.88B12.17309.
54. Clegg T.E., Roberts C.S., Greene J.W., Prather B.A. Hip dislocations – epidemiology, treatment, and outcomes. *Injury*, 2010, vol. 41, no. 4, pp. 329-334. DOI: 10.1016/j.injury.2009.08.007.
55. Surya Prakash Rao V., Chandrasekhar P., Rajasekhara A.L.V., Prasad Rao V.B.N. Results of surgically treated displaced acetabular fractures among adults. *Clin. Proc. NIMS*, 2005, vol. 17, no. 2, pp. 12-16.
56. Lapshina S.A., Mukhina R.G., Miasoutova L.I. Osteoartroz: sovremennye problemy terapii [Osteoarthrosis: modern problems of therapy]. *RMZh*, 2016, no. 2(24), pp. 95-101. (In Russ.)
57. Dezateux C., Rosendahl K. Developmental dysplasia of the hip. *Lancet*, 2007, vol. 369, no. 9572, pp. 1541-1552. DOI: 10.1016/S0140-6736(07)60710-7.
58. Dinulesku I., Dzhiuriia M., Badila A. Sovremennye metody diagnostiki i lecheniia avaskuliarnogo nekroza golovki bedra [Current techniques of diagnosis and treatment of femoral head avascular necrosis]. *Travmatologiia i Ortopediia Rossii*, 2002, no. 1, pp. 31-36. (In Russ.)
59. Makushin V.D., Safonov V.A., Danilova I.M., Mitina Iu.L. K voprosu o rannei diagnostike asepticheskogo nekroza golovki bedra u vzroslykh [The problem of early diagnosing of femoral head aseptic necrosis in adults]. *Genij Ortopedii*, 2003, no. 1, pp. 125-129. (In Russ.)
60. Leo M., Milena F., Ruggero C., Stefania S., Giancarlo T. Biophysical stimulation in osteonecrosis of the femoral head. *Indian J. Orthop*., 2009, vol. 43, no. 1, pp.17-21. DOI: 10.4103/0019-5413.45319.
61. Mustafin R.N. Asepticheskii nekroz golovki bedrennoi kosti [Aseptic necrosis of the femoral head]. *Lechebnoe Delo*, 2015, no. 4, pp. 7-20. (In Russ.)
62. Grishchuk A.N., Usol'tsev I.V. Endoprotezirovanie tazobedrennogo sustava pri posttravmaticheskikh defektakh vertluzhnoi vpadiny [Arthroplasty of the hip for posttraumatic defects of the acetabulum]. *Biulleten' VSNTs SO RAMN*, 2015, no. 6 (106), pp. 17-20. (In Russ.)
63. Ward A.J., Chesser T.J. The role of acute total hip arthroplasty in the treatment of acetabular fractures. *Injury*, 2010, vol. 41, no. 8, pp. 777-779. DOI: 10.1016/j.injury.2010.05.020.
64. Lai O., Yang J., Shen B., Zhou Z., Kang P., Pei F. Midterm results of uncemented acetabular reconstruction for posttraumatic arthritis secondary to acetabular fracture. *J. Arthroplasty*, 2011, vol. 26, no. 7, pp. 1008-1013. DOI: 10.1016/j.arth.2011.02.026.
65. Pang Q.J., Yu X., Chen X.J., Yin Z.C., He G.Z. The management of acetabular malunion with traumatic arthritis by total hip arthroplasty. *Pak. J. Med. Sci*., 2013, vol. 29, no. 1, pp. 191-196. DOI: 10.12669/pjms.291.2900.
66. Solod E.I., Lazarev A.F., Sakharnykh I.N., Stoiukhin S.S. Novye tekhnologii osteosinteza perelomov vertluzhnoi vpadiny [New technologies of osteosynthesis for acetabular fractures]. *Med. Alfavit*, 2014, no. 11 (2), pp. 6-10. (In Russ.)
67. Tikhilov R.M., Shubniakov I.I., Chiladze I.T., Karpu- khin A.S., Pliev D.G., Ambrosenkov A.V., Blizniukov

V.V., Miasoedov A.A. Total'noe endoprotezirovanie tazobedrennogo sustava s ispol'zovaniem augmentov iz trabekuliarnogo metalla pri posledstviiakh perelomov vertluzhnoi vpadiny [Total arthroplasty of the hip using augments of trabecular metal for consequences of acetabular fractures]. *Travmatologiia i Ortopediia Rossii*, 2011, no. 1 (59), pp. 76-81. (In Russ.)

68. Templeton J.E., Callaghan J.J., Goetz D.D., Sullivan P.M., Johnston R.C. Revision of a cemented acetabular component to a cementless acetabular component. A ten to fourteen-year follow-up study. *J. Bone Joint Surg. Am*., 2001, vol. 83-A, no. 11, pp. 1706-1711.
69. Karlstrom G., Broback L.G. Total hip replacement with Muller acetabular support rings. *Acta Orthop. Scand*., 1988, vol. 591, no. Suppl. 227, p. 34.

Received: 18.01.2017

Information about the authors:

1. Oleg K. Chegurov, M.D., Ph.D., Russian Ilizarov Scientific Center for Restorative Traumatology and Orthopaedics, Kurgan, Russia, Head of the Laboratory of Reconstructive Arthroplasty and Arthroscopy
2. Il'ia N. Menshchikov, M.D., Russian Ilizarov Scientific Center for Restorative Traumatology and Orthopaedics, Kurgan, Russia, postgraduate; Email: menshhikov8@mail.ru