INNOVATIVE TECHNOLOGIES IN PELVIC FRACTURES MANAGEMENT

E.I. Solod[1], A.F. Lazarev[2], N.V. Sagorodni[1], M.A. Abdulchabirov[1], A.V. Ovcharenko[3]

[1]Peoples' Friendship University of Russia, Moscow, Russia
[2]Central Institute of traumatology and orthopedics (CYTO) them.N.N.Priorov, Moscow, Russia
[3]Center of traumatology and orthopedics, Kaluga, Russia

The article is based on our clinical experience and modern tendencies of development of minimally invasive surgery. It contains analysis of percutaneus osteosynthesis of pelvic fractures with various metal fixation devices.

We analyzed 74 cases of pelvic fractures in which minimally invasive osteosynthesis was used. The patients underwent operative treatment with cannulated screws and new metal fixation devices — CITO screws. The innovative technology showed its high clinical efficiency, its advantages and weak points were analyzed.

The majority of pelvic ring injuries are life-threatening and are often accompanied by fractures of other parts of the skeleton and injuries of internal organs. High quality operative treatment of pelvic fractures is often limited by severe general condition of patients and the necessity of simultaneous operative treatment of internal organs and injured parts of musculoskeletal system.

Thus, on the one hand, it is necessary to provide high quality fixation of pelvic bone fragments, on the other hand, it is important to reduce surgical aggression during osteosynthesis. The most serious conditions are pelvic ring fractures associated with acetabular fractures, when there is need for intracapsular acetabular fracture stabilization for successful pelvic functional recovery.

Acetabular fractures still remain one of the most crucial issues of modern traumathology. Disability, low life quality, hip arthroplasty are the main sequences of inadequate treatment of such fractures.

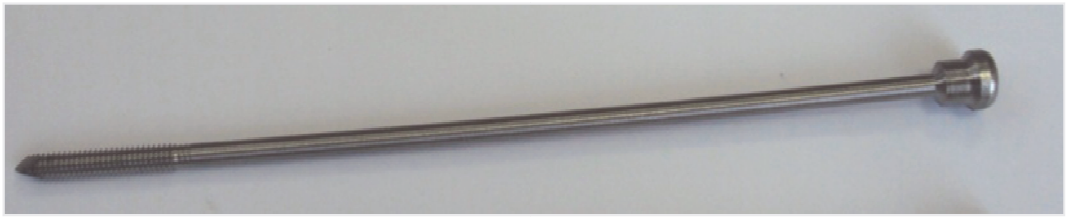
Conservative treatment results in disability in 22—66.7% cases, that is 3 times more frequent compared to the level of disability after operative treatment (1, 2, 3). Only operative treatment makes it possible to achieve successful longtime functional recovery (4).

Open reduction with internal fixation is associated with large surgical incision, massive intraoperative blood loss and high risk of infectious complications. The main recognized condition for bone fracture consolidation is intact blood supply of fragments, that is provided only by minimal surgical invasion (5, 6, 7, 8).

Thus, development and implementation of implants and minimally invasive methods of bone fragments stabilization are main innovative tendencies of internal osteosynthesis development. The aim of our research was to develop minimally invasive osteosynthesis technologies and to invent a new metal fixation device.

Key words: innovations, fractures, minimally invasive, percutaneus, osteosynthesis, acetabulum

We have invented special metal devices (CITO screws) for pelvic fractures stabilization. CITO screws have been designed in the 1st Traumathological department and are produced in Federal State Unitary Development — Central Institute of Traumathology and Orthopedics (FSUD CITO; Ministry of Health of Russian Federation). These part thread nf (fine pitch) screws are made of hi-tech titanium alloy (graduation mark BT6) and have diameter of 3 mm (pic. 1).



Pic. 1. CITO screw (photo)

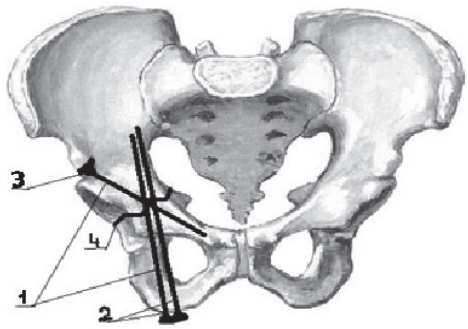
Percutaneus osteosynthesis with various metal fixation devices has been used for treatment of 74 patients (aged 17—70 years) with pelvic fractures associated with acetabular fractures in our traumathological department over the 2003—2014 period. In 64 cases for stabilization we used cannulated part thread (16 and 32 mm) screws "Synthes" AO 7.3 mm and threaded-end pins of diameter 2 mm. CITO screws were used in 10 cases.

Osteosynthesis of posterior acetabular column, anterior acetabular column and both acetabular columns was done in 12 cases (16%), 13 cases (18%) and 49 cases (66%) respectively. These cases included isolated (21 cases), multiple (26 cases) and associated (27 cases) acetabular injuries (28%, 35% and 37% respectively). Rotationally unstable pelvic ring was seen in 7 cases (31%), whereas the combination of rotational and vertical instability of pelvis was seen in 2 cases (9%). We began with stabilization of general condition of patients, therefore external osteosynthesis was done in the period of 1—3 weeks since getting trauma.

In case of pubic symphysis rupture we used Pfannenstiel incision and internal plate fixation. For acetabular osteosynthesis after closed reduction we used cannulated screws that were inserted after drilling a pilot hole with the use of a guide pin (wire) and a cannulated drill. We also used cannulated screws to fix fractures of lateral masses of the sacrum and sacroiliac joint ruptures.

CITO screws were fixed with the use of a special tool (screw collet router) without preliminary bone reaming.

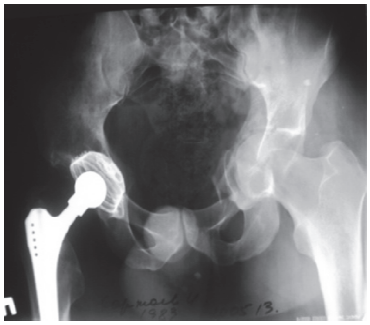
Percutaneus osteosynthesis of both acetabular columns was done under general anesthesia (patients laying supine). First, incision less than 1 cm (ischial tuberosity projection) was made, followed by bone fragments closed reduction; then extraarticular fixation of fragments with a 3,0 mm CITO screw of a necessary length was done through ischial tuberosity along ramus descendens of the ilium into the body of the ilium. Everything was done with the use of a screw collet router and an X-ray image intensifier. Then the screw collet router was open and taken out of the wound. Secondly, another 3,0 mm CITO screw was introduced through the same incision. Thirdly, a 1 cm incision 2 cm above the acetabulum is made and another 3,0 mm CITO screw is introduced through the body of the ilium and across the fracture line into the ramus superior of pubis (with the use of screw collet router). Scheme of osteosynthesis (pic. 2). The results of bone fragments reduction and osteosynthesis were assessed radiologically in pelvic frontal, obturative and iliac pelvic views.



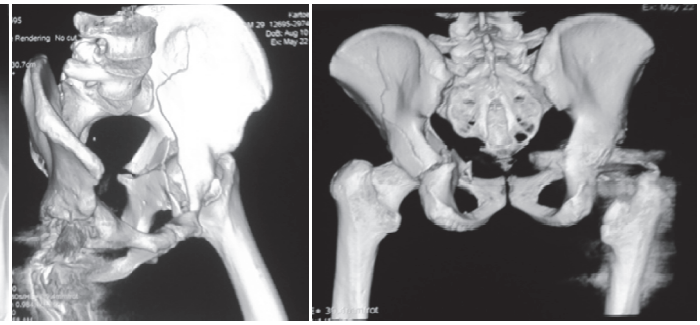
Pic. 2. Scheme of osteosynthesis:
1 — pelvic CITO screws; 2 — point of introduction of 2 pelvic CITO screws through the ischial tuberosity; 3 — point of introduction of a pelvic CITO screw 2 cm above the level of acetabulum; 4 — both acetabular columns fracture line)

Next day after operative treatment the patients sat in bed, started to walk on crutches with partial axial load of the lower limb and started exercise therapy.

Patient K., 29 years old. Traffic accident 20.05.13. Both columns fracture of the left acetabulum with the central dislocation of the femoral head. Condition after total hip right hip joint, about the fracture of the head of the right femur in 2011 (pic. 3, 4).



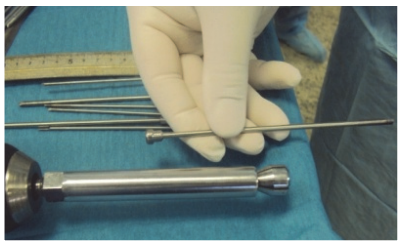
Pic. 3. Pelvic X-ray frontal view before operation

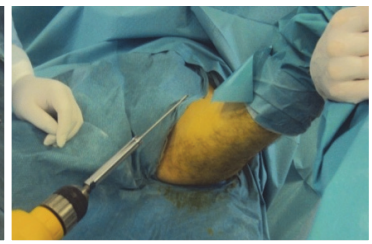


a b

Pic. 4: a — 3D reconstruction of pelvic CT; b — pelvic CT frontal image

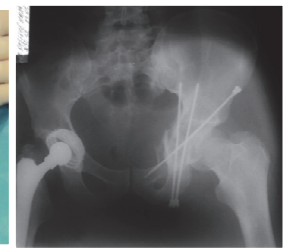
Percutaneus osteosynthesis of the left acetabular fracture (fixation with CITO screws using the mentioned above technology) was done on the 3th day after injury (fixation with CITO screws using the mentioned above technology (pic. 5, 6).





a b

Pic. 5. Steps of surgery:
a — pelvic CITO screw and screw collet router;
b — the screw is in the collet router



Pic. 6. Pelvic X-ray frontal view after operation

Next day after operation the patient started getting exercise therapy to maintain the right hip range of motions and to increase muscle tone of the limb. The stitches were removed after the wounds primary intention healing in 12 days after the surgery was performed, and the patient left the hospital for outpatient observation. Partial and whole axial load of the limb was prescribed in 6 and 8 months respectively.

Sufficient consolidation of bone fragments, acetabular congruency restitution and no signs of femoral head avascular necrosis were found in control X-ray films in 1 years after surgery. Next day after the removal of metal fixation devices the patient walks with whole axial load of the limb. The right hip range of motions is full (pic. 7).

Pic. 7. Pelvic X-ray frontal view

Patient K., 23 years old. Traffic accident 06.07.2013. Both columns fracture of the right acetabulum. Right iliac wing fracture. Right pubic inferior ramus and body fractures. Acromioclavicular joint rupture (pic. 8, 9).

Pic. 8. Pelvic X-ray frontal view

Pic. 9. 3D reconstruction of pelvic CT

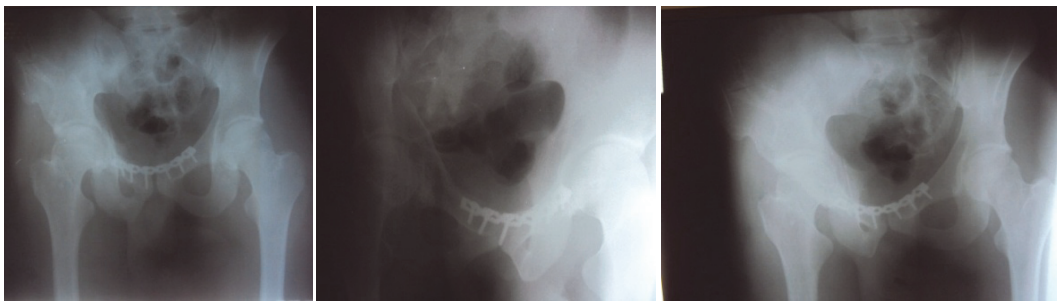
After stabilization of the general condition the patient was referred to CITO traumathological department for further examination and the following operative treatment: 1) metal plate fixation of anterior part of the pelvic ring; 2) percutaneus osteosynthesis of the right acetabular fracture and of the right iliac wing fracture 3) stabilization of the ruptured acromioclavicular joint with a hook plate (pic. 10). All surgery was done simultaneously on 10.06.2013.

a b c

Pic. 10.

a — pelvic X-ray frontal view after surgery, b — obturative pelvic view, c — iliac pelvic view

Next day after surgery the patients sat in bed, started to walk on crutches with partial axial load of the lower limb and started exercise therapy. There were no complications in the postoperative period, so the patient left the hospital for outpatient observation in 12 days after the surgery was performed. The metal fixation devices were removed from the right acetabulum on 27.12.2013 (pic. 11).



a b c

Pic. 11.

a — pelvic X-ray frontal view, b — obturative pelvic view, c — iliac pelvic view

The right hip range of motions is full, the patient has no pain complaints.

Results. The results of treatment were followed up till complete hip functional recovery (from one to 10 years of follow-up). No cases of femoral head avascular necrosis were observed. Fracture consolidation and full motion range recovery were recorded. Patients had no complaints about hip pain or pain in ischial tuberosity area.

The results were assessed according to the hips and lower limbs functional recovery and the amount of early and long-term complications. The mean duration of hospitalization was 14 days. The dynamic follow-up included three periods: early postoperative period — up to 14 days after surgery, medium-dated postoperative period — from 6 months up to one year after surgery, and long-term postoperative period — more than a year after surgery.

Minimally invasive surgery techniques made it possible for patients to start doing therapeutic physical exercises in 1—2 days after surgery. The results were evaluated using Harris Hip Scope, mean score was 85,7. The patients reported good physical activity, low pain level and in some cases no pain at all.

Long-term X-ray observations showed full fracture consolidation, the posttraumatic arthrosis was also observed, but no cases of femoral head avascular necrosis were seen. Full functional recovery and social and medical rehabilitation were achieved in all cases. No massive blood loss made it possible to perform simultaneous surgery on extrapelvic injured parts of the body. No inflammation or sciatic neuropathy were observed in the postoperative period.

Discussion. Minimally invasive osteosynthesis of pelvic ring fractures with cannulated screws and pins is becoming widespread in Russia and other countries. Sufficient blood supply of bone fragments depends on the degree of surgical invasion and the contact area between the bone surface and the implant.

Minimization of surgical invasion and of the implant size makes it possible to perform early internal osteosynthesis and simultaneous stabilization of all fractured areas without disturbing bone fragments and soft tissues blood supply, thus creating biological conditions for their healing, consolidation and regeneration.

Pin migration in long-term postoperative period can be a complication of minimally invasive osteosynthesis with cannulated screws and pins. The free end of the pin lies in soft tissues and can cause pain and heterotopic ossification. The cannulated screw is too wide, thus devitalization of bone fragments and narrow intramedullar canal of the anterior column make it difficult to insert the screw into the superior ramus of pubic bone; sometimes it results in acetabular cavity perforation by external part of the screw.

Technical difficulties can be caused by the necessity of drilling a pilot hole for the cannulated screw: the guide pin (wire) often “leaves” the pilot hole together with the drill, therefore previously achieved reposition of bone fragments might be lost. The removal of cannulated screws can also become a problem as their coarse pitch thread overgrows with bone tissue.

According to international clinical experience and research the small diameter of screws is beneficial in percutaneous osteosynthesis of acetabular fractures. In addition, the small diameter of the screws does not affect biomechanical stability of fixation (9, 10, 11, 12).

Clinical and standing trial data, scientific approach to finding the optimal form of the screw and minimal but sufficient for pelvic bone safe fixation diameter of the screw has made us invent CITO screws with the diameter of 3 mm.

The screw small diameter nearly that of a pin is beneficial in case of comminuted displaced acetabular fractures with a tendency towards femoral head central dislocation. The use of such screws makes it possible to insert two screws from 1,0 cm incision, saves the main bone frame of the column so that the forces are applied proportionally; therefore, there are conditions for doing therapeutical physical exercises in early postoperative period and for acetabular congruency restitution and no conditions for bone fragments secondary devitalization.

The 1,0 cm incision also allows insertion of screws in different directions and iliac bone osteosynthesis. The length of screws varies from 5,0 to 17,0 cm; the choice in each case depends on the type and the level of the fracture line. Such factors as small screw diameter and no need for drilling a pilot hole facilitate osteosynthesis of lateral masses of the sacrum and sacroiliac joint fixation. There is a small risk of perforation of the screw into sacral foramina.

Small step thread of CITO screws is sufficient to create good bone fragments compression. At the same time the design of screws allows their easy removal after bone fragments consolidation.

Surgical treatment of pelvic ring fractures with CITO screws significantly reduces time of surgery, eliminates massive blood loss and intraoperative trauma of intraarticular parts of the hip, capsula and femoral head, prevents postoperative complications such as sciatic nerve neuropathy and femoral head avascular necrosis, saves soft tissues and bone fragments blood supply, and allows for simultaneous osteosynthesis in case of multiple fractures.

Early simultaneous fixation of such fractures promotes fast stabilization of patients general condition and their early physical activity and prevents hypostatic complications in case of multiple injuries, thus reducing the time of bed rest and inpatient care.

The aims of introduction of innovative metal fixation devices and minimally invasive osteosynthesis development include fragments indirect reduction and minimization of surgical incision and of contact area between the bone surface and the implant, that contribute to better bone fragments consolidation and prevent inflammation. According to our experience the use of these innovative technologies is justified by lower economic burden and medical staff work optimization and helps to save compensatory resources of the human body that are needed for successful recovery after such dangerous injuries.

Conclusion. The use of CITO screws for pelvic ring fractures osteosynthesis facilitates the work of the surgeon and improves the results of treatment:

1. The implant is inserted more accurately, the surgical incision is small.
2. The screw does not require a pilot hole.
3. The diameter of 3,0 mm makes it possible to insert several screws from 1 cm incision in case of comminuted displaced acetabular fractures.
4. The contact area between the bone surface and the implant is reduced.
5. The amount of surgical manipulations is reduced; therefore, the joint, femoral bone and soft tissue intraoperative damage is also reduced.
6. The time of surgery and the amount of blood loss are reduced.
7. The removal of metal fixation devices becomes easier.

REFERENCES

[1] Dorzhiev C.S. Treatment of unstable pelvic ring injuries and their consequences by external fixation. Author. Dis. candidate honey. Sciences. Moscow, 2008.

[2] Yakimov S.A. Long-term results of surgical and conservative treatment of injuries of bones and joints of the pelvis. Diss. cand. honey. science. 2000. P. 79—101.

[3] Brenneman F.D., Redelmeier D.A., Boulanger B.R. et al. // J. Trauma. 1997. V. 42 (5). P. 778—781.

[4] Samohvalov I.M., Ganin V.N., Borisov M.B., Rozbitsky V.V., Rowing A.R., Denisenko V.V., Ganin E.V. Using minimally invasive osteosynthesis for fractures of the acetabulum. Military-Medical Academy. Kirov, St. Petersburg, 2013.
[5] Lazarev A.F. Surgical treatment of pelvic injuries. Author. Dis. Dr. med. Sciences. Moscow, 1992; 38.
[6] Lytvyna E.A. Modern surgical treatment of multiple and associated bone fractures of extremities and pelvis. Abstract 2010.
[7] Solod E.I., Lazarev A.F., Lazarev A.A., Gudushauri Y.G., Kakabadze M.G., Roskidaylo A.S., Dan I.M. The possibilities of surgical treatment of acetabular fractures using minimally invasive technologies. Bulletin of traumatology and orthopedics named after NN Priorov. No 2 April-June 2009. P. 3—9.
[8] Vershinin A.V., Skoroglyadov A.V. The treatment of acetabular fractures in the acute phase of injury // Journal of physical education in the prevention, treatment and reabilitatsii. Moscow, 2004. № 3. P. 59—60.
[9] Routt M.L., Simonia P.T., Grujic L. The retrograde medullary superior pubic ramus screw for the treatment of anterior pelvic ring disruptions: a new technique. J Orthop Trauma 1995;9:35—44.
[10] Gay S.B., Sistrom C., Wang G.J., et al. Percutaneous screw fixation of acetabular fractures with CT guidance: preliminary results of a new technique. AJR Am J Roentgenol 1992; 158:819—22.
[11] Attias N., Lindsey R.W., Starr A.J., et al. The use of a virtual three-dimensional model to evaluate the intraosseous space available for percutaneous screw fixation of acetabular fractures. J Bone Joint Surg [Br] 2005;87:1520–3.
[12] Chen et al. Differences of percutaneous retrograde screw fixation of anterior column acetabular fractures between male and female: A study of 164 virtual three-dimensional models. Injury. Int. J. Care Injured 40 (2009) 1067—1072.

ИННОВАЦИОННЫЕ ТЕХНОЛОГИИ ПРИ ЛЕЧЕНИИ ПЕРЕЛОМОВ КОСТЕЙ ТАЗА

Э.И. Солод[1], А.Ф. Лазарев[2], Н.В. Загородний[1], М.А. Абдулхабиров[1], А.В. Овчаренко[3]

[1]Российский университет дружбы народов, Москва, Россия
[2]ЦИТО им. Н.Н. Приорова, Москва, Россия
[3]Центр травматологии и ортопедии, Калуга, Россия

Статья написана на основе клинического опыта авторов и современных тенденций развития малоинвазивной хирургии. В ней содержится анализ случаев выполнения чрескожного остеосинтеза переломов костей таза с использованием различных металлических фиксаторов.

Мы проанализировали 74 случая переломов костей таза, в которых был использован малоинвазивный остеосинтез. Пациентам проведено оперативное лечение канюлированными винтами и новыми металлическими фиксаторами — ЦИТО-винтами. Инновационные технологии показали ее высокую клиническую эффективность, ее преимущества и слабые места, которые были проанализированы авторами.

Большинство травм малого таза являются опасными для жизни и часто сопровождаются переломами других частей скелета и повреждениями внутренних органов. Высокое качество оперативного лечения переломов таза часто ограничивается тяжелым общим состоянием больных и необходимостью одновременного оперативного лечения травм внутренних органов и поврежденных участков опорно-двигательного аппарата.

Таким образом, с одной стороны, необходимо обеспечить высокое качество синтеза фрагментов тазовой кости, а с другой стороны, важно уменьшить хирургическую агрессию во время остеосинтеза. Самыми серьезными являются кольцевые переломы таза, связанные с вертлужной впадиной, когда есть необходимость интракапсулярной стабилизации перелома вертлужной впадины для успешного функционального восстановления органов малого таза.

Переломы вертлужной впадины по-прежнему остаются одним из наиболее важных вопросов современной травматологии. Инвалидность, низкое качество жизни, эндопротезирование тазобедренного сустава являются главными последствиями неадекватного лечения таких переломов.

Консервативное лечение приводит к инвалидности в 22—66,7% случаев, что в 3 раза чаще по сравнению с уровнем инвалидности после оперативного лечения (1; 2; 3). Только оперативное лечение позволяет достичь успешного функционального восстановления (4).

Открытая репозиция с внутренней фиксацией связана с большим хирургическим разрезом, массивной интраоперационной кровопотерей и высоким риском инфекционных осложнений. Главное условие для костной консолидации перелома — сохранение кровоснабжения отломков, что обеспечивает только минимальное хирургическое вторжение (5; 6; 7; 8).

Таким образом, разработка и внедрение имплантатов и малоинвазивные методы стабилизации костных отломков — основные инновационные тенденции развития внутреннего остеосинтеза. Целью нашего исследования явилась разработка малоинвазивных технологий остеосинтеза и изобретение нового устройства металлического остеосинтеза.

Ключевые слова: инновации, переломы, малоинвазивный, чрескожный, остеосинтез вертлужной впадины

БИБЛИОГРАФИЧЕСКИЙ СПИСОК

[1] Доржиев Ч.С. Лечение нестабильных повреждений тазового кольца и их последствий методом наружной фиксации:. Автореф. дис. ... канд. мед. наук. М., 2008.

[2] Якимов С.А. Отдаленные результаты оперативного и консервативного лечения повреждений костей и сочленений таза: Дисс. канд. ... мед. наук. 2000. С. 79—101.

[3] Brenneman F.D., Redelmeier D.A., Boulanger B.R. et al. // J. Trauma. 1997. V. 42 (5). P. 778—781.

[4] Самохвалов И.М., Ганин В.Н., Борисов М.Б., Розбицкий В.В., Гребнев А.Р., Денисенко В.В., Ганин Е.В. Использование малоинвазивного остеосинтеза при переломах вертлужной впадины. Военно-медицинская академия им. С.М. Кирова. СПб., 2013.

[5] Лазарев А.Ф. Оперативное лечение повреждений таза: Автореф. дис. ... д-ра мед. наук. М., 1992.

[6] Литвина Е.А. Современное хирургическое лечение множественных и сочетанных переломов костей конечностей и таза: Автореферат 2010.

[7] Солод Э.И., Лазарев А.Ф., Лазарев А.А., Гудушаури Я.Г., Какабадзе М.Г., Роскидайло А.С., Дан И.М. Возможности оперативного лечения переломов вертлужной впадины с использованием малоинвазивных технологий // Вестник травматологии и ортопедии имени Н.Н. Приорова. 2009. № 2 апрель—июнь. С. 3—9.

[8] Вершинин А.В., Скороглядов А.В. Лечение переломов вертлужной впадины в остром периоде травмы // Журнал физкультура в профилактике, лечении и реабилитации. М., 2004. № 3. С. 59—60.

[9] Routt M.L., Simonia P.T., Grujic L. The retrograde medullary superior pubic ramus screw for the treatment of anterior pelvic ring disruptions: a new technique // J Orthop Trauma 1995. N 9. P. 35—44.

[10] Gay S.B., Sistrom C., Wang G.J. et al. Percutaneous screw fixation of acetabular fractures with CT guidance: preliminary results of a new technique // AJR Am J Roentgenol. 1992. N 158. P. 819—822.

[11] Attias N., Lindsey R.W., Starr A.J. et al. The use of a virtual three-dimensional model to evaluate the intraosseous space available for percutaneous screw fixation of acetabular fractures // J Bone Joint Surg [Br]. 2005. No 87. P. 1520—1523.

[12] Chen et al. Differences of percutaneous retrograde screw fixation of anterior column acetabular fractures between male and female: A study of 164 virtual three-dimensional models // Injury, Int. J. Care Injured. 2009. N 40. P. 1067—1072.