



Experience in early minimally invasive fixation of pubic symphysis disruption with a system of transpedicular screws in patients with combined pelvic trauma (pilot study)

A.V. Petrov¹✉, I.V. Kazhanov^{1,2,3}, V.I. Badalov², S.I. Mikityuk^{1,2}, R.A. Presnov¹, V.A. Manukovsky¹, Ya.V. Gavrishuk¹, E.A. Kolchanov¹

¹ Dzhanelidze Saint Petersburg Research Institute of Emergency Medicine, Saint Petersburg, Russian Federation

² Kirov Military Medical Academy, Saint Petersburg, Russian Federation

³ Pavlov First Saint Petersburg State Medical University, Saint Petersburg, Russian Federation

Corresponding author: Artem V. Petrov, seductor@yandex.ru

Abstract

Introduction Challenges of treating the injuries of pubic symphysis in patients with combined pelvic injury require developing new techniques for stable minimally invasive osteosynthesis in the acute period of trauma.

Purpose of the work was to assess the application of low invasive fixation of the pubic symphysis with a system of transpedicular screws in the patients with combined unstable pelvic injuries in the acute period of the traumatic disease.

Materials and methods The results of treatment of 12 patients with polytrauma with unstable pelvic injury with rupture of the pubic symphysis who were treated at Dzhanelidze Research Institute of Emergency Medicine, St. Petersburg, in the period from 2017 to 2023, were analyzed. All the patients underwent final minimally invasive fixation of the pubic symphysis with a system of transpedicular screws in the early period of the traumatic disease.

Results The overall assessment of the results in 12 patients found no complications or technical errors during the installation of transpedicular screws. Control CT scans of the pelvis showed that osteosynthesis was stable in all patients, and the position of metal was correct in all. One patient from the study group died in the clinic from massive pulmonary embolism. The long-term results in 11 patients in the period from 6 months to 3 years after trauma were evaluated as excellent and good anatomical and functional results in 10 patients, one case had fair outcome.

Discussion The use of bone plates to fix ruptures of the symphysis pubis leads to disruption of its physiological mobility, and the patient's activity in the postoperative period can cause an implant fracture. Original dynamic plates and wire cerclage help avoid this complication; however, all these techniques involve significant surgical trauma and blood loss, as well as the risk of postoperative wound suppuration. Minimally invasive methods of fixation using cannulated screws, systems such as Endobutton, Tight Rope can reduce intraoperative trauma and the risk of complications (blood loss, suppuration); however, the procedure for their installation is quite complex and lengthy, and for greater stability, external fixation of the pelvic ring is often required. The proposed minimally invasive fixation of the pubic symphysis with a system of transpedicular screws avoids a lot of shortcomings and is sufficiently stable.

Conclusion The method of minimally invasive fixation of the pubic symphysis with a system of transpedicular screws meets current requirements in the treatment of patients with polytrauma and unstable pelvic injury, and it may be successfully used in the acute period of trauma.

Keywords: rupture symphysis pubis, combined injury, minimally invasive osteosynthesis, pedicle screws, osteosynthesis of the pubic articulation

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INTRODUCTION

Disruption of the pubic symphysis, as a component of unstable pelvic ring injury, occurs in 13–15 % of patients with combined trauma. In the structure of injuries to the anterior pelvic ring, isolated symphyseal disruption occurs in 8.9 % of cases, in combination with fractures of the pubic and ischial bones in 7.1 % of cases. Disruption of the pubic symphysis usually results from a high-energy mechanism of injury [1, 2, 3].

The use of the external fixator (EF) for temporary stabilization of the pelvis in the early stages after trauma has become the "gold standard" in trauma surgery, while the final fixation of the pelvic ring, including the pubic symphysis, is frequently performed after stabilizing the patient's condition [4, 5]. Conservative treatment of traumatic pubic symphysis disruption is often ineffective and leads to a significant number of poor results (20–25 %), which are associated with unresolved symphysis reduction, inadequate fixation, concomitant sacroiliac joint disruptions, various sacral fractures, and post-traumatic deformation of the pelvic ring [1, 2].

The accepted optimal method for restoring the anatomy of the pelvic ring is osteosynthesis with internal constructs. Systems for internal fixation of the pubic symphysis range from screws with cerclages to plates of various designs [6, 7, 8]. Traditional methods of bone osteosynthesis of the pelvic bones are commonly invasive, so they cannot always be applied in severe conditions of the injured. For this reason, the development of various minimally invasive methods for fixation of the pubic symphysis continues.

Current treatment approach for unstable pelvic injuries in combined trauma is based on the concept of Orthopedic Damage Control and is part of the algorithm for treating severe trauma — ATLS (Advanced Trauma Life Support). This involves measures to eliminate life-threatening consequences of trauma, temporary stabilization of the pelvic ring with an EFA, prevention of infectious complications. Then, stabilization of the general condition is conducted, and prevention and treatment of complications are carried out. Subsequently, during the period of relative or complete compensation of the body's vital functions, the final osteosynthesis of pelvic bone fractures is performed.

At present, the problem of choosing the optimal method of internal fixation for ruptures of the symphysis pubis remains acute, since many issues on this topic have been insufficiently studied and are controversial. Obviously, there is a need to continue research on the development and improvement of optimal methods of internal fixation for unstable pelvic injuries with rupture of the pubic symphysis in the acute period of injury, based on the principles of minimally invasive osteosynthesis.

Purpose of the work was to assess the application of low invasive fixation of the pubic symphysis with a system of transpedicular screws in the patients with combined unstable pelvic injuries in the acute period of the traumatic disease.

MATERIALS AND METHODS

Treatment results of 12 patients with combined pelvic trauma were analyzed, who sustained unstable injury to the pelvic ring accompanied by a rupture of the pubic symphysis, and who were hospitalized at the Dzhanelidze Research Institute of Emergency Medicine (first level trauma center, St. Petersburg) from 2017 to 2023.

During the examination upon admission of the patients, specialists from the anti-shock team established the mechanism and circumstances of the injury, carried out instrumental diagnostics, and assessed the severity of the condition and injury.

The structure of unstable injuries of the pelvic ring according to the classification of Muller AO-OTA/ASIF [15] was as follows: A2 — 1 case (8.4 %), B1 — 3 cases (25.0 %), B2 — 2 cases (16.5 %), B3 — 1 case (8.4 %), C1 — 5 cases (41.6 %) (Table 1).

All patients underwent minimally invasive fixation of the pubic symphysis with a transpedicular system in the acute period of the traumatic disease.

There were 7 (58.4 %) males and 5 (41.6 %) females. Circumstances of injuries were fall from a height in 5 cases (41.6 %), road traffic accidents such as vehicle injury in 3 cases (25.0 %), one motorcycle injury (8.4 %), compression injury under load in 3 (25.0 %). The average age of the patients was (37.6 ± 10.9) years.

Criteria for inclusion in the study group were working age (from 18 to 65 years), mild traumatic brain injury (AIS scale ≤ 4 points), morphology of damage to the pelvic ring that allowed to use minimally invasive internal fixation of the pubic symphysis with a system of transpedicular screws: isolated (rupture of the symphysis with a divergence of more than 2.5 cm or with an overlap) or in combination with cannulated screws (a combination of rupture of the symphysis with fractures of the horizontal ramus of the pubic bone in the Nakatani II–III region).

In the patients with combined trauma in the acute period of the traumatic disease, to make tactical decisions, we used the authors' tactics of differentiated specialized high-tech surgical care for pelvic injuries, developed by our team, which allows us to take into account the criteria for the risk of developing a lethal outcome and to differentiate in detail patients according to the prognosis for poor outcome. Thus, the optimal sequence of therapeutic and diagnostic measures was built. The severity of the injury was determined in scores on the ISS and MFS-P (MT) scales, the age of the patients was considered (as a criterion for comorbidity), the severity of traumatic brain injury was assessed using the Glasgow Coma Scale [16], and the mechanism of pelvic injury was assessed by Young – Burgess classification [17]. Using the developed logit model, the probability of an unfavorable or favorable outcome was predicted in a binary system [18]. Thus, the average severity of injury was (23.2 ± 12.4) points according to ISS and (7.9 ± 4.6) points according to MFS-P (MT) (Table 1).

Table 1

Data on the injured individuals included in the study that had pubic symphysis disruption

#	Age	Sex	Injury cause	Mechanism of pelvic injury	AO/OTA	ISS	MFS-P	Associated injuries
1	57	m	Road accident (passenger)	Complete rupture of sacroiliac ligament (APC III)	C1.2.	41	17.8	Brain concussion. Multiple bilateral rib fractures. Lung contusion. Extraperitoneal bladder rupture
2	47	f	Traffic accident (driver)	Fracture of the pubis with involvement of the anterior column of the acetabulum (low fracture), of the ischium, fracture of the sacrum (Denis 1) (type LCI)	B2.1.	34	8.1	Moderate brain contusion. Multiple rib fractures. Lung contusion. Heart bruise. Hemopneumothorax. Grade 3 splenic rupture. Closed fracture of the left humerus
3	55	m	Compression	Partial rupture of the sacroiliac ligament (APC II)	B1.1.	13	3.1	Brain concussion
4	34	m	Catarauma	Fracture of the pubic and both ischial bones, Fracture of the sacrum (Denis 2) (type VS)	C1.3.	27	9.8	Brain concussion. Lung contusion. Compression fracture of the body of Th12, L2 vertebrae, stage 2. Open fracture of the calcaneus. Extensive damage to the soft tissues of the pelvis according to the Morel – Lavallee type
5	28	m	Catarauma	Sacrum fracture (Denis 2) (type VS)	C1.3.	17	8.9	Brain concussion. Lung contusion
6	32	f	Catarauma	Sacrum fracture (Denis 2) (type VS)	C1.3.	14	7.3	Brain concussion

Continuation of Table 1

Data on the injured individuals included in the study that had pubic symphysis disruption

#	Age	Sex	Injury cause	Mechanism of pelvic injury	AO/OTA	ISS	MFS-P	Associated injuries
7	19	f	Mototrauma (driver)	Pubic bone fracture, partial rupture of the sacroiliac ligament (APC II)	B1.1.	10	3.3	Brain concussion
8	32	f	Compression	Partial rupture of sacroiliac ligament (APC II)	B3.1.	10	3.2	Brain concussion. Vaginal rupture, stage 2
9	44	m	Road accident (passenger)	Partial rupture of sacroiliac ligament. Butterfly fracture of both pubic and ischial bones (APC II)	B1.1.	9	6.2	Brain concussion. Perineal rupture. Lacerated and bruised wound of the scrotum
10	46	f	Catarauma	Partial rupture of the symphysis pubis. Butterfly fracture of both pubic and ischial bones (LCI)	A2.3.	13	3.5	Moderate brain contusion. Orbital wall fracture
11	32	m	Compression	Fracture of both pubic and ischial bones. Sacrum fracture (Denis 2) (LCI)	B2.1.	9	6.2	Brain concussion. Posterior urethral rupture
12	30	m	Catarauma	Fracture of both pubic and ischial bones. Sacrum fracture (Denis 1) (VS type)	C1.3.	36	16.3	Moderate brain contusion. Multiple rib fractures. Lung contusion. Hemopneumothorax. Closed fracture of the proximal femur. Posterior urethral rupture

The severity of traumatic brain injury according to the Glasgow Coma Scale was (14.1 ± 1.3) points. Upon admission, seven (58.4 %) patients had life-threatening consequences of injuries that required emergency surgical interventions: ongoing intra-abdominal bleeding in one patient, tension pneumothorax in one, and ongoing external bleeding in two patients. In that group, five (41.6 %) patients were found to have ongoing intrapelvic bleeding, therefore, to achieve final surgical hemostasis, angiography with embolization was used in two cases and extraperitoneal pelvic tamponade was used in one case, and anti-shock sacroiliac screws were used in all patients in the mentioned group. The life-threatening consequences of the injury were eliminated in the anti-shock operating room soon after admission to the trauma center.

Multiple injury to the pelvis was diagnosed in six patients (50 %): rupture of the posterior urethra was present in two (16.5 %), extraperitoneal rupture of the bladder, rupture of the vagina, extensive damage to the soft tissues of the pelvis according to the Morel – Lavallee, perineal rupture (one case of each).

All the admitted underwent spiral computed tomography (SCT) in the anti-shock department of the trauma center of five areas of the body (head, chest, spine, abdomen and pelvis) according to the “Polytrauma” program on a Toshiba Aquilion PRIME 128 CT system (Japan). While assessing pelvic scans, the morphology of damage to the pelvic ring was clarified. If damage to internal organs and blood vessels was suspected, SCT was supplemented with contrast support.

The final minimally invasive internal osteosynthesis of the damaged structures of the unstable pelvic ring was carried out in five patients during the acute period of the traumatic disease immediately upon admission, and in two patients after preliminary extrafocal stabilization of the pelvis during the period of relative stabilization of their condition (48–72 hours after the injury).

To fix the pubic symphysis, a system was used consisting of two locking transpedicular screws inserted into the vertical branches of the pubic bones from top to bottom and connected by a metal rod. The assessment of the position of bone structures and metal structures was carried out

using polypositional fluoroscopy on a General Electric OEC 9900 Elit C-arm (USA). After indirect reduction on an orthopedic table with the elimination of all types of displacement in the unstable pelvic ring, the anterior semi-ring was initially fixed with internal metal structures or EF, and then osteosynthesis of the damaged posterior pelvic structures was performed.

Minimally invasive fixation of the pubic symphysis with a system of transpedicular screws was performed according to the developed method with minimal tissue trauma: metal implants were installed through small incisions, only the heads of the transpedicular screws were in contact with the periosteum, the rest of the element were located epiperiosteally. Thus, the contact of the implants with the periosteum was reduced, which allowed minimal disturbance of blood supply to the bone [19].

Short-term results of treatment were assessed using the VAS scale, which allows one to objectively assess the subjective satisfaction (based on a range from 0 to 10, where 0 indicates maximum dissatisfaction, and 10 complete satisfaction), the duration of bed rest was considered.

All patients after internal pelvic osteosynthesis underwent a control study to assess the position of the metal structures and restoration of the anatomy of the pelvic ring. To assess long-term results, 11 patients were observed at the following time-points: after 6 weeks, 3 months, 6 months, and 12 months after surgery and annually thereafter for up to three years. Functional treatment results were evaluated using the Majeed scale, including such criteria as pain, the ability to sit and walk, the ability to have sexual intercourse and perform labor activities (work) [20].

Functional abilities and quality of life in 11 patients were determined using the nonspecific SF-36 questionnaire, reflecting general well-being and satisfaction, those aspects of the patient's life that affect the state of the health [21]. The SF-36 questionnaire consists of 36 questions grouped into eight scales. They form two parameters: psychological and physical components of health.

The database of patients was created in Microsoft Office Excel 2010. Descriptive statistics methods were used to analyze the data. Given that the study did not compare groups, normally distributed continuous data were expressed as mean $\pm$ standard deviation. Statistical analysis of the data was carried out using the BioStat 2009 program (Analyst Soft Inc., USA).

RESULTS

The majority of patients with a favorable outcome, determined using the developed prognostic logit model, underwent internal fixation of the injured pelvis in the first hours after injury. A patient with a vaginal rupture underwent suturing; two patients with a rupture of the posterior urethra underwent cystotomy, urethral tunnelization according to Albarran – Vishnevsky and drainage of paravesical tissue according to Buyalsky – McWhorter.

In all the cases, the rupture of the pubic symphysis was synthesized with a system of transpedicular screws according to the proposed method. To treat injuries to the posterior structures of the pelvis, sacroiliac cannulated screws were additionally used. In three cases, rupture of the symphysis was accompanied by unilateral or bilateral fractures of the rami of the pubic bone, for osteosynthesis of which cannulated screws were installed using the antegrade technique. The surgical procedure was completed with fixation of the symphysis pubis using the proposed transpedicular system. In three patients with type C1.3 pelvic ring injury, for reliable fixation of damaged posterior structures, in addition to fixation with sacroiliac cannulated screws, a unilateral lumbopelvic system based on transpedicular screws was installed using a minimally invasive technique.

Two patients with an unfavorable prognosis underwent temporary fixation of the pelvis with an EF system for elimination of diastasis in the symphysis pubis and fixation of the posterior structures with sacroiliac cannulated screws (combined osteosynthesis) in the anti-shock operating room. One patient underwent laparotomy and splenectomy to stop ongoing intra-abdominal bleeding,

and one patient underwent extraperitoneal pelvic tamponade. Two days later, one patient (after removal of tampons from the pelvic cavity) underwent final suturing of an extraperitoneal rupture of the bladder with the application of a cystostomy and drainage of paravesical tissue. During the period of relative stabilization of the condition (from 1 to 3 days), those patients underwent stabilization of the damaged pelvic structures: dismantling of the EF, internal antegrade osteosynthesis of the fracture of the horizontal ramus of the pubic bone with a cannulated screw, and fixation of the pubic symphysis with a minimally invasive transpedicular system.

Fixation of the pubic symphysis with a minimally invasive method using a transpedicular system was accompanied by small intraoperative blood loss, and the risks of infectious complications decreased. Surgical access with this technique retains impermeability of the prevesical space that contributed to the preservation of biological tamponade and reduced the risk of intrapelvic bleeding. One patient developed massive pulmonary embolism 5 days after the operation, which was the cause of death. Visceral complications associated with combined trauma were also observed: pneumonia in three cases, including the development of sepsis in one of them. Local complications such as bedsores over the heads of transpedicular screws or suppuration of postoperative wounds were not observed when using this method of fixation of the pubic symphysis in the studied group. The average period of bed rest ranged from 3 to 12 days after injury and depended on the nature of the damage and the severity of the condition.

None of the patients had iatrogenic complications, technical errors in internal osteosynthesis, or malposition of transpedicular screws in the area of the pubic symphysis according to checking SCT of the pelvis. The average length of hospital stay was (31.3 ± 13.9) days. The average level of pain on the VAS scale was (3.4 ± 1.2) points. In one patient, after discharge, a screw migrated through the anterior cortical plate of the pubic bone (he constantly violated the treatment regimen). This required removing the system 1.5 months after installing it.

The long-term results of treatment were studied in 11 patients; a quantitative assessment of the functional state of the pelvis according to Majeed was (87.8 ± 12.2) points (min — 61, max — 100). Ten patients had an excellent or good result, and one had a fair treatment result. The fair result was due to secondary displacement of fragments in the posterior semi-ring and partial dysfunction of the pelvic organs (Table 2).

According to the final nonspecific questionnaire SF-36 to assess the quality of life, five patients showed good results on selected scales (the higher the value of the indicator from 0 to 100, the better the score on the selected scale), primarily reflecting the physical component of health (Table 3).

Table 2

Majeed functional scores (1989)

Majeed scale parameters	Mean score, $M \pm m$	
Mean score	87.8 ± 12.2	
Pain (30 points)	26.8 ± 4.0	
Work (20 points)	17.1 ± 3.6	
Sitting ability (10 points)	8.5 ± 1.6	
Sexual intercourse (4 points)	3.5 ± 0.5	
Standing ability (12 points)	11.2 ± 1.8	
Gait (12 points)	9.5 ± 2.7	
Walking (12 points)	11.1 ± 1.4	
Clinical evaluation of the results:	number	%
Excellent	7	63.6
Good	3	27.3
Fair	1	9.1
Poor	0	

Table 3

SF-36 questionnaire results, $n = 11$

Quality of life parameters	Mean score, $M \pm m$
Physical health	
Physical functioning, points	67.7 ± 31.3
Physical role, points	65.9 ± 28.0
Pain, points	69.1 ± 24.5
General health, points	69.4 ± 16.8
Emotional components of health	
Vitality, points	69.5 ± 18.2
Social function, points	44.5 ± 10.2
Emotional role, points	82.0 ± 27.1
Mental health, points	73.7 ± 17.6
Physical health component, points	44.5 ± 9.2
Emotional health component, points	48.5 ± 7.9

The results obtained indicate the effectiveness of the chosen treatment tactics, the correct choice of implants and their combinations for final stable internal fixation.

Case report

Patient G., 54 years old, was admitted to the trauma center one hour after injury (compression of the pelvis with a heavy load). A combined injury with rotationally unstable injury to the pelvic ring was diagnosed: ruptures of the pubic and right sacroiliac joints (Tile BI); acute blood loss; shock stage I. In the anti-shock department, the general condition was of moderate severity, blood pressure was 125/85 mm Hg, rhythmic pulse, heart rate 75 beats/min. Consciousness on the Glasgow Coma Scale was 15 points. The severity of injury on the ISS scale was 13 points. Upon examination, clinical signs of unstable pelvic injury were identified and temporary fixation with a pelvic belt (T-POD, USA) was immediately performed. SCT of the pelvis revealed a rupture of the symphysis pubis with a diastasis of 2.5 cm, and a partial rupture of the right sacroiliac joint (Fig. 1).

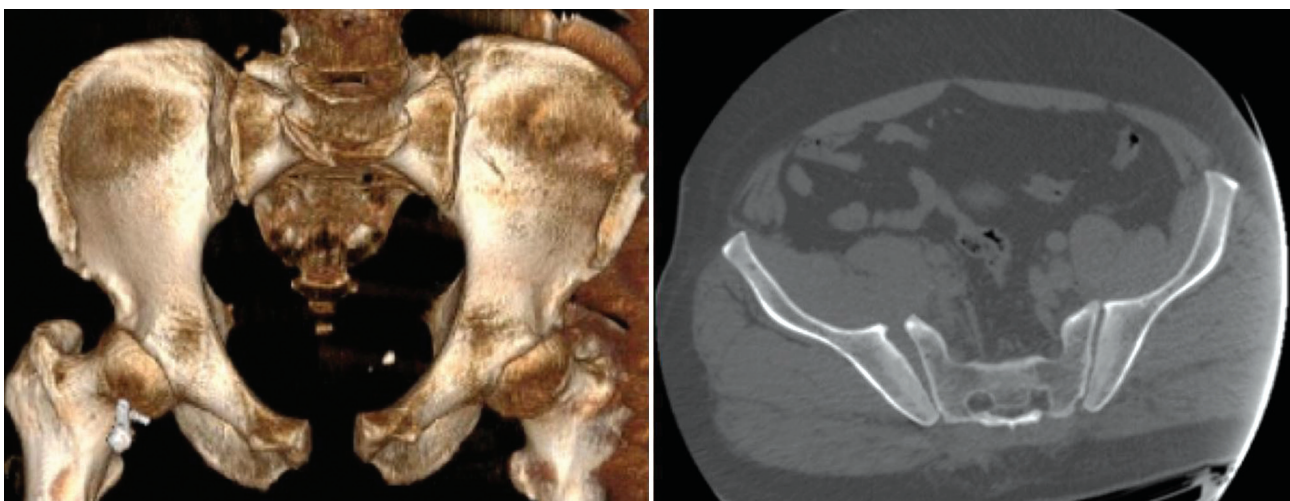


Fig. 1 SCT of patient G. at admission

The diastasis in the pubic symphysis was eliminated and fixed with a transpedicular system according to the described minimally invasive technique soon after admission. The right sacroiliac joint was fixed with a sacroiliac cannulated screw (Fig. 2).

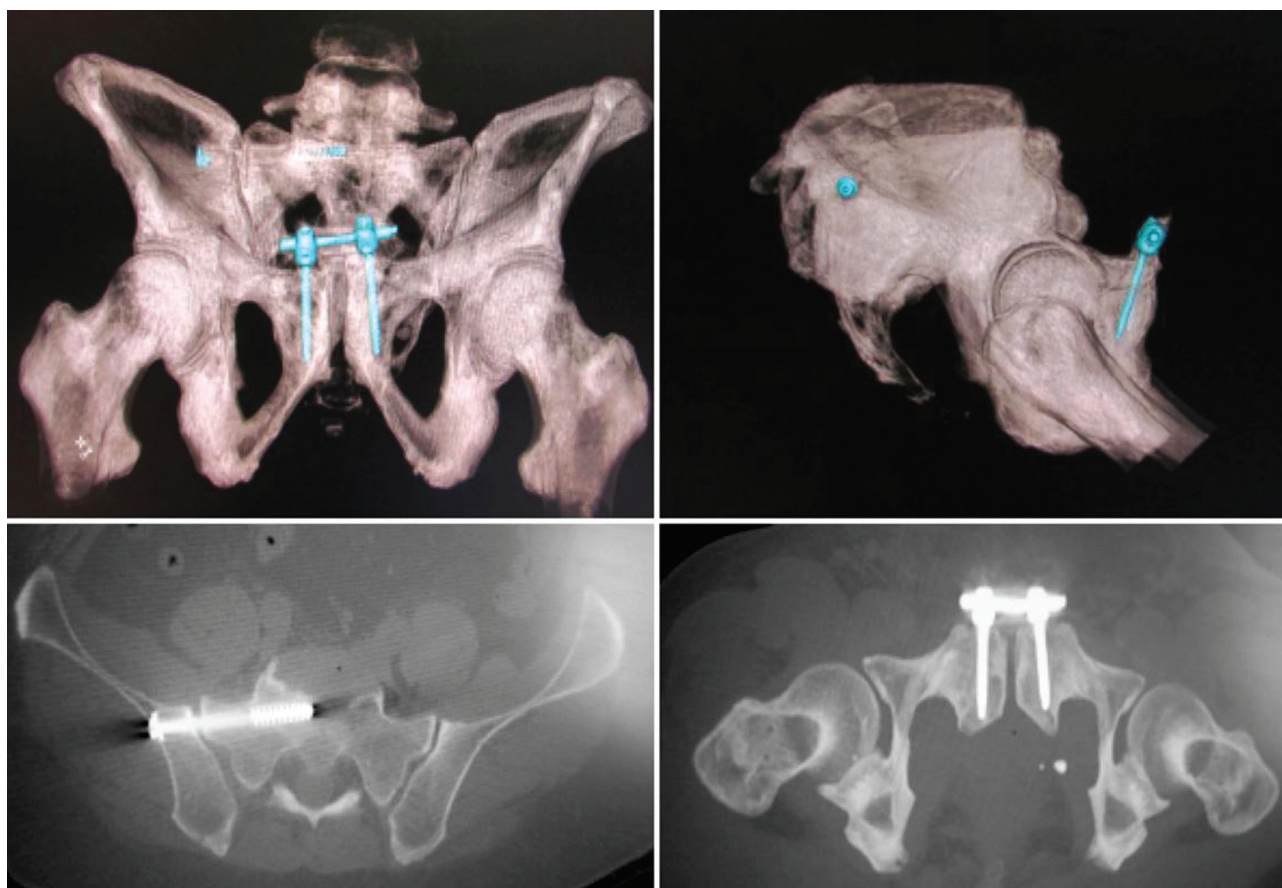


Fig. 2 SCT of patient G. after the operation

The patient was activated in bed from the third day after surgery. Walking with crutches with a dosed weight-bearing on the right lower limb was recommended. The patient was discharged for outpatient treatment after 20 days. The metal structures of the pelvis were completely removed 6 months after discharge. After 18 months the patient was re-examined, good treatment results were revealed: Majeed score — 98 points; SF-36 score: physical functioning — 95, physical role functioning — 100, pain — 100, general health — 85, general physical health component (PH) — 57.4 points.

The patients gave their voluntary informed consent for the publication of their clinical findings.

DISCUSSION

Recovery of vital body functions and treatment of complications may take a fairly long time after polytrauma (up to 3–4 weeks or more). Surgical interventions in the pelvic area performed during such a long period are traumatic, accompanied by large blood loss and a high risk of iatrogenic damage [6, 22].

Various surgical treatment methods have been proposed to fix the pubic symphysis. An external fixation device used in the acute period of injury is also applicable as a method of final stabilization of the damaged pubic symphysis. The operation is low-traumatic, takes relatively little time, and allows the patient to be mobilized early. The advantage of such fixation of the pubic symphysis is the patient's early activation and relatively good tolerance of the fixator. The use of EF is indicated up to four weeks after injury and in the presence of inflammatory changes in the area of the pubic symphysis and unorganized hematoma. However, the disadvantages of EF are also known: the need for constant care of pin tracts in the area, an increased risk of tissue suppuration around the pin wounds, loosening and migration of transosseous elements, the inability of the EF to retain the reduction of the posterior structures of the pelvis which can lead to early secondary displacement of fragments [2, 4].

The most common technique, presented as the “gold standard,” is open plating of the pubic symphysis. Some authors classify it as a low-traumatic intervention and consider it possible to fix the pubic symphysis with a plate simultaneously with laparotomy or pelvic tamponade in emergency care [14, 23]. For this purpose, DCP, LC-DCP or special reconstruction plates are frequently used. The plates are installed superiorly and/or anteriorly relative to the pubic symphysis. This method of fixation achieves absolute (static) stability of the pubic symphysis, which can provoke a fatigue fracture of the plate in the postoperative period ($> 23\text{--}30\%$ of clinical observations), since physiological mobility in the joint is disrupted when the patient becomes active, and loosening and subsequent failure of the implant lead to repeated diastasis in the pubic symphysis, persistent pain syndrome and severe impairment of static and dynamic functions [24, 25].

Ananyin et al. described the use of an original dynamic pelvic plate installed on the pubic symphysis, which, in their opinion, provides physiological micromobility in the joint and dynamic but stable fixation of the pelvic ring [26].

All these methods involve dissection of the rectus abdominis muscles in surgical approaches, which increases the risk of damage to the bladder and large vessels [14, 22]. The use of one plate along the upper edge of the symphysis for rotationally unstable pelvic injuries is sufficient to stabilize the pelvic ring. For vertically unstable pelvic injuries, two plates are used along the upper and anterior surface of the symphysis with the simultaneous installation of two iliosacral screws on the side of a complete rupture of the sacroiliac joint [27]. Simonian et al. show equally high efficiency in stabilizing the pelvis both with installing a plate on top of the symphysis on two and four 4.5 or 3.5 thick screws, and with installing two plates on six screws. Also, biomechanical bench studies of this author show that the most durable design for stabilizing a rupture of the pubic symphysis is biplanar fixation of the pubic symphysis with anterior and superior plates or a specially designed biplanar “box plate” [28].

Chen et al. evaluated the symphysis fixation technique that included the use of the Endobutton technique. After a mean follow-up of 23 months (range, 18 to 26 months), 15 patients achieved excellent Majeed scores with no migration of implants [10].

Recently, an innovative method of spare surgery for ruptures of the pubic symphysis has been proposed using new types of Tight Rope fixators for dynamic percutaneous stabilization with successful results. The fixator itself consists of two metal buttons (round and oblong) connected by a continuous self-tightening loop made of fibrous thread, which allows manual tightening, without tying a knot, and intraoperative adjustment of the degree of cortical fixation. This dynamic implant in the surgical treatment of ruptures of the pubic symphysis provides semi-rigid and durable fixation, allowing minor physiological movements, which reduces the load on the fixator itself, being a successful alternative method for the treatment of traumatic diastasis of the symphysis pubis type II, leading to results similar to percutaneous fixation with cannulated screws. Additional external fixation of the pelvic ring provides greater stability in the early postoperative phase. The best indication for the use of Tight Rope fixators is APC-II type pelvic injuries (type B1 or B2 in accordance with the accepted Tile classification). The authors state that the advantages of the four-point fixation system are a minimally invasive installation technique, less intraoperative blood loss, minimal risk of complications and rapid recovery [9]. Secure dynamic bone fixation reduces the load on the pubic symphysis during ligament healing and micromotion, which decreases the risk of implant failure. There is no need to remove the implant. Disadvantages are the complex procedure and a relatively longer operating time. Contraindications to the use of the method are open pelvic injuries, combined fractures of the acetabulum, fractures of the anterior semi-ring of the pelvis in combination with ruptures of the symphysis pubis and medical contraindications. Subsequent clinical experience and biomechanical studies regarding this method of dynamic implant fixation may facilitate its use in more complex clinical cases, such as APC-III pelvic injuries, in which simultaneous stabilization of damaged posterior pelvic ring structures is required.

There is evidence of percutaneous fixation of the pubic symphysis with cannulated screws. We may discuss several options for inserting cannulated screws, when the screws are located parallel to each other (horizontally or obliquely) and when they cross each other. Yu et al. compared this surgical technique with plate fixation of the symphysis pubis in a study of clinical and biomechanical outcomes. The authors noted a significantly shorter operative time (26 versus 69 minutes) and less intraoperative blood loss (10 versus 172 ml) in the screw fixation group. At a mean 29-month follow-up (range, 18 to 54 months), measuring the pubic symphysis diastasis in each group, a similar distance in the screw and plate fixation groups (4.8 vs. 4.5 mm) was found [27]. Similarly, Chen et al. conducted a retrospective comparative study of the results of treatment of patients who underwent fixation of the pubic symphysis with cannulated screws or plates. A significantly less blood loss in the screw fixation group (18 vs. 157 mL) was found. However, according to the results of 21 months (range, 18 to 26 months) there was little difference in the incidence of complications such as revision surgery (2 vs. 6), infection (2 vs. 8), or symphyseal malunion (8 vs. 14) [29]. A biomechanical study by Cano-Luis et al. concluded that there is sufficiently good rigidity in fixing a rupture of the symphysis pubis with two cannulated screws [30]. The authors of those studies concluded that percutaneous fixation may achieve similar results to plate fixation reducing operative time and blood loss. Thus, minimally invasive fixation of the symphysis pubis with cannulated screws reduces the risk of intraoperative complications, but does not significantly improve treatment results compared to fixation with plates.

There are known methods for fixing the symphysis pubis using metal flexible implants with thermometallic memory made of NiTi (titanium nickelide). The authors indicate that their use enabled them to achieve good fixation and micromobility in the area of the symphysis pubis [31]. There is also a known method for fixing ruptures of the pubic symphysis with sets of U-shaped staples [11]. However, that method involves a traumatic approach and there is the risk of bladder damage. The proposed metal structures are not manufactured at an industrial scale.

Osteosynthesis of the symphysis pubis with various types of wire cerclage is rarely used in modern conditions due to traumatic approaches and unstable fixation; it is rather of historical significance. However, according to a biomechanical study carried out by Varga et al., wire cerclage fixed to two cancellous screws, the optimal diameter of which is 6.5 mm with continuous threading, inserted into the rami of the pubic bones parasymphysially, may achieve fixation that, while being functionally stable, prevents synostosis of the pubic symphysis [32].

As for surgical approaches for the symphysis pubis fixation, it is worth mentioning the classic Pfannenstiel approach, which is used most, and the ilioinguinal approach as modified by Stopp, which is considered less traumatic [14, 34]. As one of the low-traumatic and fairly well-known approaches to the symphysis pubis, a vertical median approach has been proposed, which allows for good exposure of the symphysis pubis with the articulating bones, which provides sufficient conditions for applying a plate or installing transpedicular screws [34]. Thus, the aponeurosis of the rectus abdominis muscles is not crossed, and there is less risk of vascular damage. The vertical midline approach should be considered as an alternative to classical approaches for the use of minimally invasive transpedicular screw fixation techniques.

All of the above methods of fixation of the symphysis pubis require classical open surgical approaches to the pubic symphysis with their inherent disadvantages [6, 22, 35]. Lately, a variant of fixation of the symphysis pubis with endoscopic support was described [36].

At the moment, the scientific research conducted by us includes a small number of clinical observations, which does not allow for a full statistical analysis of the effectiveness of the proven method of minimally invasive fixation of ruptures of the symphysis pubis, and the reliability of the final results has not been fully reflected. To obtain more complete clinical data, further study is required with a larger sample size and a longer observation period, a comparative

analysis with the use of other methods of fixation of the symphysis pubis. Biomechanical studies of this technique are also necessary.

However, the success of using the method under consideration in our clinical practice for various injuries of the pelvic ring, including for vertically unstable injuries, multiple pelvic trauma (open injury with perineal rupture, extensive soft tissue injuries of the Morel – Lavallee type, ruptures of the pelvic organs), allows us to recommend its study within the framework of surgery for injuries of the pelvic ring and fractures of the acetabulum as an interdisciplinary pathology at the intersection of various specialties. Future research should focus on the long-term outcomes and effectiveness of new innovative techniques for fixation of pubic symphysis ruptures.

CONCLUSION

The minimally invasive fixation of the pubic symphysis with a transpedicular system proposed by us corresponds to the principles of current minimally invasive pelvic osteosynthesis. Due to its low-traumatic nature, it may be used in the acute period of a traumatic disease, ensuring early rehabilitation.

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Information about the authors:

Artem V. Petrov — traumatologist-orthopedist, seductor@yandex.ru;

Igor V. Kazhanov — Doctor of Medical Sciences, leading researcher, Associate Professor, carta400@rambler.ru;

Vadim I. Badalov — Doctor of Medical Sciences, Professor, Head of Department, vadim_badalov@mail.ru;

Sergey I. Mikityuk — Candidate of Medical Sciences, senior lecturer, head of the department, smikityuk@yandex.ru;

Roman A. Presnov — traumatologist-orthopedist, gingel_presnov@list.ru;

Vadim A. Manukovsky — Doctor of Medical Sciences, Professor, Director, sekr@emergency.spb.ru;

Yaroslav V. Gavrishuk — Candidate of Medical Sciences, head of the department, gavyaros@mail.ru;

Evgeniy A. Kolchanov — head of the surgical department, dr_kolchanov@mail.ru.