

Pubic Rami Fractures Fixation by Interlocking Intramedullary Nail: First Clinical Experience

P.A. Ivanov, N.N. Zadneprovsky, A.V. Nevedrov, V.O. Kalensky

Sklifosovsky Clinical and Research Institute for Emergency Care, Moscow, Russian Federation

Abstract


Background. Growing number of patients with pelvic fractures is associated with evolution of high-speed transport, high-rise construction and industrial production. The optimal surgical procedure for pubic rami fractures must ensure a stable fixation and simultaneously minimize the risk of postoperative complications. Purpose the study was to evaluate the efficiency of a new technique for pubic bones fixation by a titanium nail in patients with pelvic fractures. **Materials and Methods.** The authors present the experience on treatment of 18 patients who underwent 25 surgeries for internal fixation of pubic rami fractures by a designed solid titanium nail. Mean age of patients was 40.16 ± 10.35 years. Proposed surgical method provides for mandatory use of image intensifier during all stages of the procedure. With patient in a supine position the authors performed internal fixation of pubic bones by a retrograde nail inserted using a navigating handle through a skin incision of 1 cm in the area of symphysis. After complete insertion into the bone the nail was interlocked proximally by two 3.5 mm cortex screws through an additional skin incision of 1.0 cm using a navigating handle and guiding sleeves. All pelvic ring fractures were classified according to AO/OTA classification and pubic fractures by Nakatani classification. Functional outcome was evaluated by Majeed score. **Results.** Bilateral fractures were diagnosed in 7 (38.8%) patients (floating pubic symphysis). 13 (72.2%) patients featured polytrauma with average ISS score of 25.1 ± 7.8 . 2 (11,1%) patients were diagnosed with open pelvic fractures, 3 (16.6%) patients had a concomitant acetabular fracture. The authors performed epicystostomy in two (11.1%) patients and laparotomy bringing out the drainages in 5 (27,8%) patients. Mean follow up was 7.8 ± 6.2 months. Stable fixation was obtained in all patients. By the moment of the present publication X-ray healing of pubic bones was observed in 16 (64%) cases, in remaining 9 (36%) cases the follow up period was less than mean healing period (2 months). In 11 (68.8%) patients the functional outcome averaged 91 ± 3.9 by Majeed score 6 months postoperatively, in 8 (50%) patients – 93.8 ± 2.9 by Majeed score 12 months postoperatively and more. No complications like skin necrosis, secondary fragments displacement or infection were not observed. **Conclusion.** Preliminary results demonstrated the absence of wound infection and reliable fragments fixation. This technique can be applied in patients with stomas and drainages upon the anterior abdominal wall which extends the indication range for surgical treatment of anterior pelvic ring. High fixation properties of proposed nailing create conditions for early mobilization of the patients and for conducting the exercise therapy.


Keywords: pubic rami fractures, pelvic fractures, internal fixation of pubic bone, interlocking nail.

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 **Nikita N. Zadneprovskiy;** e-mail: zacuta2011@gmail.com

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Introduction

Growing number of patients with pelvic fractures is associated with evolution of high-speed transport, high-rise construction and industrial production [1–3]. With that anterior and posterior pelvic ring structures are equally affected. There is the reason to consider restoration of posterior pelvic anatomy [4] as the primary goal. This principle postulates for pelvic stabilization to arrest intrapelvic bleeding and for the maximal restoration of the bearing function of the bony pelvic ring [5, 6]. Current theories as well as treatment algorithms reflect exactly such ideas –to fix posterior segment of pelvic ring as soon as possible [5, 7, 8] in the less traumatic manner and providing mechanical stability. With that, accompanying fractures of pubic and sciatic bones are often given little significance and disproportionately less attention is given to their early or delayed fixation.

Rate of pubic rami fractures according to R.M. Hill et al is 6.9 cases per 100 000 in the population younger than 60 years old and 25.6 cases in population older 60 years [9]. In younger patients the pubic rami fractures occur in result of high energy trauma especially associated with unstable pelvic fractures. Quite often pelvic fracture is an element of a combined and polytrauma which aggravates the general status of the patient and complicates the treatment of combined injuries, especially at the resuscitation stage when damage control algorithm dictates urgent pelvic ring stabilization as part of anti-shock measures [10, 11]. In elderly patients isolated fractures of pubic bones are diagnosed more often. As a rule, such fractures are low-energy but are often accompanied by a severe pain syndrome with loss of support ability and abrupt limitation of mobility. Conservative treatment with prolonged bed care for elderly patients is often combined with development of hypostatic pneumonia, decubitus ulcers and thromboembolic complications [7].

In the authors' opinion surgical fixation of anterior pelvic ring has a major importance for pelvic ring stability as a whole. This opinion is supported by some publications, where authors prove that secure stability of anterior pelvic structures significantly improves mechanical rigidity of the whole pelvic ring provided fixation of posterior fractures [12, 13]. This contributes to relief of pain syndrome and assists earlier mobilization of injured and supports prophylaxis of complications related to long bed care.

Currently used methods for anterior pelvic ring injuries fixation feature essential faults. External fixator doesn't provide conditions for good reduction and sufficient stability of bone fragments and can cause soft tissues inflammation around Schanz screws, create discomfort for the patient and inconvenience for examination and treatment [14]. Plate fixation demands extensive exposure, there is a risk of large vessels injury, and development of infectious complications in postoperative period. Minimally invasive screw fixation is combined with a high risk of implant migration and secondary fragments displacement, not mentioning the intricate surgical technique. These and other drawbacks of available techniques often force the surgeons to reject surgical fixation of anterior pelvic structures in favor of conservative treatment which dictates long bed stay for the patient [15].

The circumstances above constituted the ground for conducting a research aiming at creation of a new device for anterior pelvic half-ring fixation. In the result the authors developed a new surgical technique of pubic rami fractures fixation which stipulates the use of a unique internal locked fixator which ensures high fixation stability. The authors suggest a minimally invasive and safe internal fixation technique using the new device.

Purpose of the study — to evaluate the efficiency of a radically new technique for pubic bones fixation in patients with pelvic fractures.

Materials and Methods

In the period from December 2016 till December 2017 the authors fixed 25 fractures of pubic bones in 18 patients (10 women and 8 men) using the proposed surgical method. Mean age of patients was 40.16 ± 10.35 years (27–64 years). Bilateral pubic fractures were diagnosed in 7 patients (38.8%) (Table).

Table

Pubic rami fractures distribution according to Nakatani classification [16]

Fracture type	Left	Right	Total
I	1	3	4
II	6	9	15
III	3	3	6
Total	10	15	25

Patients with pubic symphysis rupture in addition to pubic bones fractures were not included into the present study.

According to the algorithm of the authors' institution, the first stage of treatment included pelvic immobilization by pin external fixators in all patients with clear signs of pelvic ring instability. In some cases anti-shock

C-clamp was additionally applied for posterior pelvic structures fixation. In patients with uncertain symptoms of pelvis instability the immobilization was gained by pelvic bandages or not applied at all. After general stabilization of the patient the second stage of treatment included definitive minimally invasive internal fixation of posterior half-ring pelvic fractures by cannulated screws and internal fixation of pubic rami bones by interlocking nails.

In patients with multiple and combined fractures the injury severity was assessed by ISS score, fractures of pelvic ring were assessed by AO/OTA classification, pubic fractures — by Nakatani classification [16, 20] (Fig. 1).

Indications for internal fixation of pubic rami fractures by proposed technique included:

- 1) vertically unstable pelvic fractures with fixed injuries of posterior pelvic half-ring by cannulated screws (61-c);
- 2) pelvic fractures resulting from lateral compression (61-B);
- 3) Fractures in all zones by Nakatani.

Contraindications: extremely narrow intramedullary cavity of pubic bone at the side of injury (less than 3 mm on X-ray) and presence of infection immediately at the area of nail or locking screws insertion. A relative contraindication was presence of non-mobile pubic fragments with inability to perform closed reduction (in this case it's possible to switch to semi-closed or open reduction of pubic bone fragments).

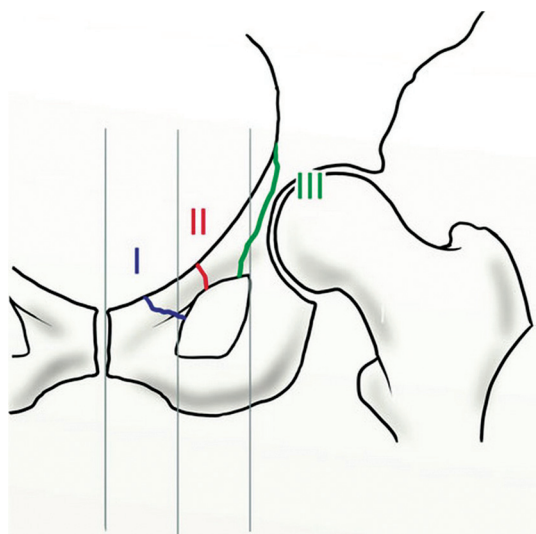


Fig. 1. The three types of the Nakatani classification system of pubic rami fractures: type I fractures medial of the obturator foramen; type II fractures of the middle zone; type III fractures lateral to the obturator foramen [20]

X-ray control of quality and outcomes of fixation was made in 1, 2, 3, 6 and 12 months postoperatively, in Judet, inlet, outlet projections and in standard overall pelvic view. Functional outcome was evaluated by Majeed score in 6 and 12 months postoperatively.

The authors managed to evaluate roentgenological and functional outcomes in 16 patients. One patient died due to severe craniocerebral injury and one patient refused from cooperation and further follow up.

Designed fixator and proposed surgical technique

The designed intramedullary fixator is made of titanium alloy and has 3 length options (110, 120 and 130 mm). The nail has a cylindrical form along the whole length (Fig. 2a). Nail diameter at the site of connection with guiding device is 5 mm with gradual conical taper up to 3.5 mm. There are two transverse open-end holes in the widest part of the nail, 3.8 mm in diameter, located 5 mm from each other, to enable nail interlocking. For internal fixation of pubic bone the nail was connected with guiding device consisting of two parts (handle and cover plate) and a connecting screw. Cover plate of the guid-

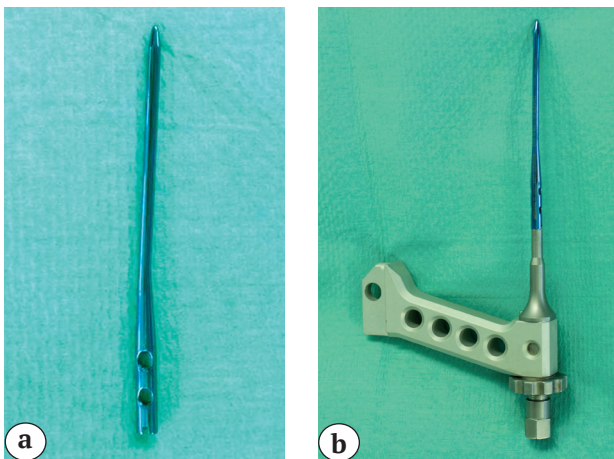


Fig. 2. The interlocking nail for pubic rami osteosynthesis (a); the nail in the handle of the targeting device (b)

ing device has two open-end holes for placing protective sleeves and for locking the nail by 3.5 mm screws using a screwdriver (Fig. 2b).

The patient was placed on the surgical radiolucent table with rollers under knee joints to ensure 20–30° flexion. Foley catheter was applied to control diuresis and monitor intraoperative bladder injuries. Image intensifier was used during the whole surgical procedure to ensure intraoperative x-ray control of fragments reduction as well as nail and locking screws positioning. Surgical incision of 1 cm was made in the area of the superior border of pubic symphysis.

Scalpel blade end reached anterior superior angle of pubic bone body in the zone of medial pubic tubercle (tuberculum pubicum) immediately under the pubic crest (crista pubica). The operator was located on the opposite side to the pubic fracture site. 2.0 mm guiding wire was inserted using a cylindrical soft tissue protecting sleeve through the superior angle of pubic bone along its superior branch under image intensifier in inlet and outlet projections, trying to avoid perforation of the other cortical wall (Fig. 3).

Drilling of the anterior cortical wall of pubic bone was done under the image intensifier by a cannulated 6mm drill bit over the guiding wire (Fig. 4).

Nail fixed in the guiding device was inserted intraosseously through the surgical incision from intact side of the pelvis (Fig. 5).

Nail passing from distal fragment into the proximal fragment of pubic bone was done under image intensifier in inlet and outlet projections. Nail was introduced into the pubic bone by guiding device until its complete insertion in the bone in the inlet view. 1cm skin incision on the anterior abdominal wall was made for locking screws. This incision was used for drilling of holes in the bone by a 2.5 mm drill bit through the protective sleeve. Drill bit and protective sleeve were consecutively removed and the nail was locked by two self-tapping 3,5 mm screws of corresponding length (Fig. 6).

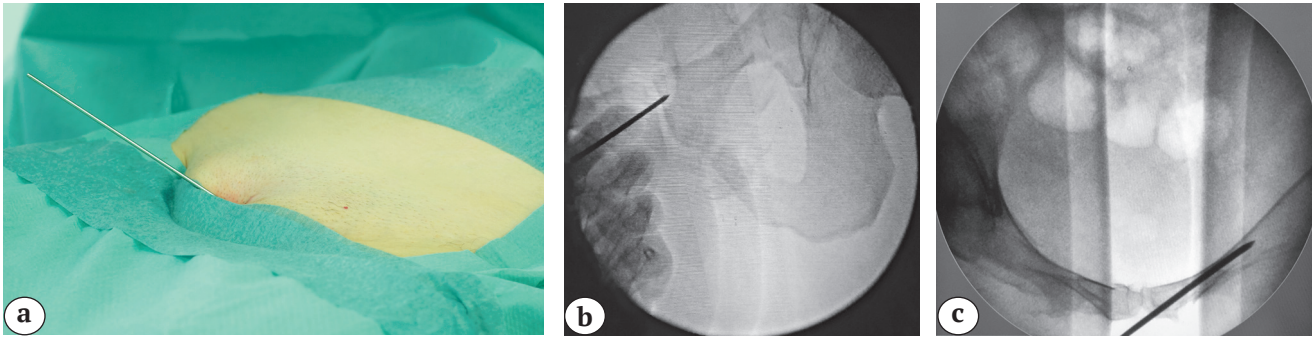


Fig. 3. Insertion of the guide wire into the distal fragment of the pubic bone:
a – photo; b – image intensifier control (outlet view); c – image intensifier control (inlet view)

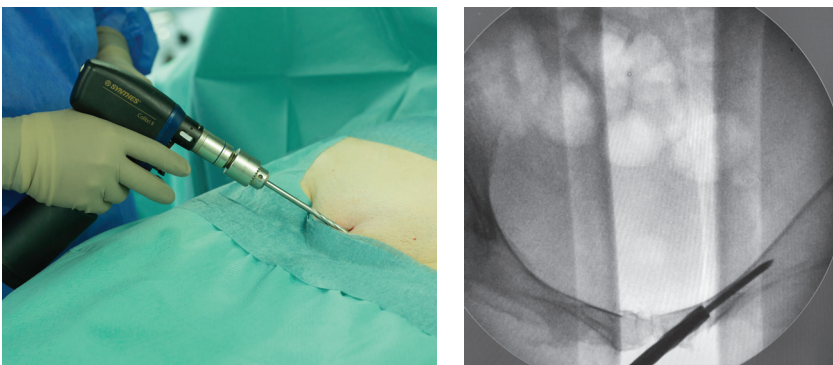


Fig. 4. Perforating of the outer cortical wall of the pubic bone

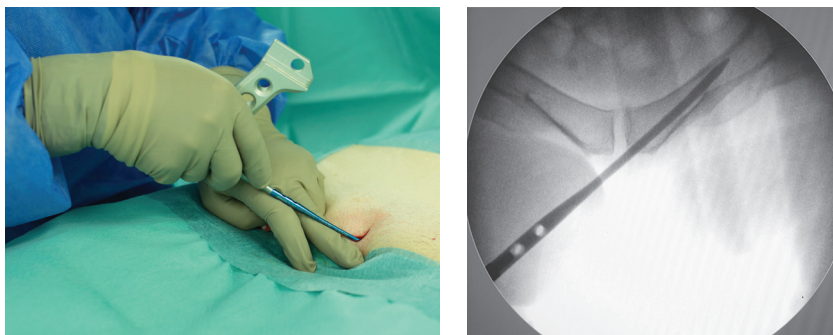


Fig. 5. Pubic bone osteosynthesis. Insertion of the nail from the distal to the proximal fragment of the pubic bone

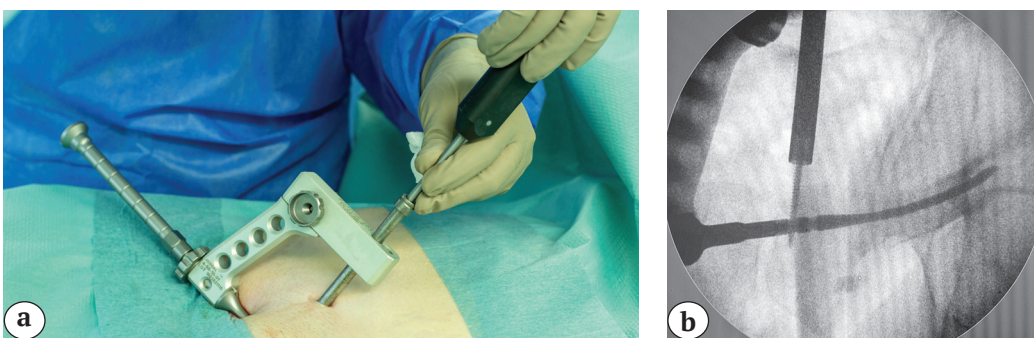


Fig. 6. Placement of the locking screws using a screwdriver through the targeting device (a);
nail interlocking using a 3.5 mm self-tapping screw (b)

Use of two locking screws excludes the nail migration along intramedullary canal and its axial rotation. Final intraoperative x-ray was done to control nail and locking screws position inside the bone.

Guiding device was then detached from the nail and removed from the surgical wound (Fig. 7). Then the wound was sutured, and sutures covered by aseptically dressings.

After pubic fracture fixation the stabilization of posterior pelvic half-ring was achieved by cannulated screws in a minimally invasive manner. In 4 patients (22.2%) the posterior fixation was done as a next stage after C-clamp removal on days 1–4 after the

clamp application. Sacroiliac joint ruptures were fixed by cannulated lag screws of 6,5mm and/or 7,3mm in diameter with partial thread (32 mm). Sacrum fractures were fixed by positioning cannulated screws of 6.5 mm and/or 7.3 mm with full thread at the S1 and/or S2 level (Fig. 8).

Patients who underwent treatment according to described technique were allowed mobilization and therapeutic exercises next day after the surgery. Patients with severe multiple and combined trauma were allowed to turn to side and over to abdomen to avoid decubitus and thrombogenesis. Sutures were removed on days 10–14 after the procedure.

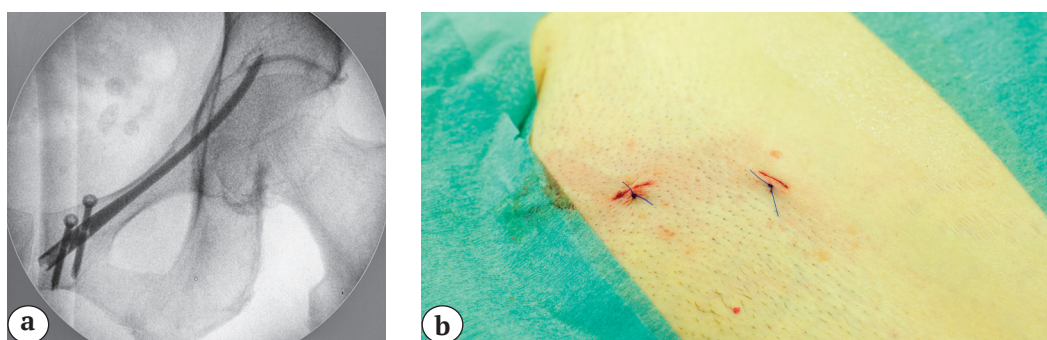


Fig. 7. Final X-ray image after fixation of the pubic rami fracture with the interlocking nail (a); postoperative view after osteosynthesis surgical field after wounds closure; surgical field after wounds closure (b)

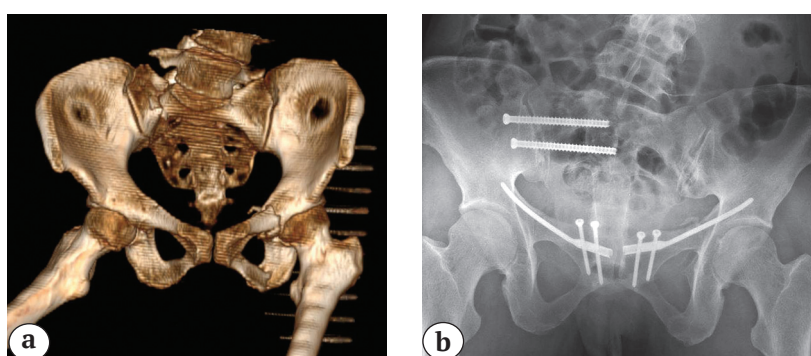


Fig. 8. Osteosynthesis of pubic rami fractures using the interlocking nailing technique: pelvic fracture AO/OTA 61-B, pubic bone fractures (Nakatani III – right, Nakatani II – left) (a); final X-ray image after fixation of the pubic rami fractures with the interlocking nails and fixation of the sacrum with two cannulated screws (b)

Results

Mean follow up term was 7.8 ± 6.2 months (from 1 to 24 months). Average ISS score was 25.1 ± 7.8 (from 11 to 41) points. Thirteen (72.2%) patients sustained pelvic ring fractures as part of multiple and combined injuries, 3 patients (16,7%) had an accompanying acetabulum fracture, 2 patients (11.11%) had an open pelvic fracture.

A type pelvic ring fracture on AO/OTA classification was diagnosed in 1 patient (5.6%), B type — in 11 patients (61.1%), C type — in 6 patients (33.3%). External fixator was used to stabilize pelvic ring in 10 patients (55.6%).

The authors reported the following distribution according to mechanism of pelvic injury: fall from a height — 8 cases (44.4%), road traffic accident — 7 cases (38.9%), others (railroad trauma, airplane crash, industrial accident) — 3 cases (16.7%).

The authors performed laparotomy in 5 patients (27.8%) due to injury of abdominal organs, epicystostomy was done in 2 patients (11,1%) in suprapubic area due to bladder injury.

Mean time from admission to internal fixation of pubic bones was 6.12 ± 2.9 (from 1 to 14) days, mean surgical time for pubic rami fracture fixation by interlocked nail — 37.6 ± 17.3 minutes, mean intraoperative blood loss — 8.6 ± 3.2 ml.

By the moment of writing the present paper x-ray signs of pubic bones healing was observed in 16 cases (64%), in other 9 cases (36%) follow up term was less than mean healing term (2 months).

6 months postoperatively the functional outcome in 11 patients (68.8%) averaged $91 \pm 3,9$ by Majeed score. 12 months postoperatively and later, 8 patients (50%) demonstrated average Majeed score of 93.8 ± 2.9 . No neurological complications, surgical site inflammation, implant migration and secondary pubic bone fragments displacement was observed in all clinical cases.

Discussion

Until now conservative treatment of pubic rami fractures is applied more often in the clinical practice than operative treatment and is accompanied by induced long term immobilization of the patient, continuous pain syndrome, late functional recovery and high rate of dangerous hypostatic complications [1]. Besides, conservative treatment can't always provide for pelvis anatomy restoration leading to healing of anterior pelvis half-ring fragments in malposition [5]. In turn, post-traumatic deformity of anterior half-ring provokes dysuria, erectile dysfunction in men and loss of reproductive function in women [17]. Surgical procedures to stabilize pelvic injuries were developed in order to improve treatment outcomes of patients with pubic rami fractures.

At present there are three major surgical fixation methods of pubic rami fractures: extrafocal by external pin fixators, open reduction and internal plate fixation, and finally, minimally invasive fixation by cannulated screws. The authors have to mention another two methods that are not so widespread in the clinical practice. One of those is subcutaneous fragments fixation of anterior half-ring by plates — Pelvic Bridge [2]. Another one (INFIX) consists of transpedicular screws placement into both pelvic half-rings, then those screws are connected to each other by a connective bar [18].

The most widespread is pubic rami fracture fixation by external pin fixators. Advantages of such method are evident — minimally invasive technique, availability of devices and relative simplicity. However, reinsertion of Schanz screws and re-mounting of fixator is needed in 12–64% of cases due to inflammatory complication. 4% of cases feature injuries of lateral cutaneous femoral nerve, so called “Bernhardt-Roth syndrome” [1, 19].

Second of the most frequently applied methods is the minimally invasive fixation by cannulated screws. Pubic rami fractures in

zones I and II according to Nakatani are the most optimal for retrograde screws fixation, in zone II — for antegrade screw insertion [16]. However, loss of fixation and implants migration were reported in 15% of cases. There is a risk of injury to femoral vessels and hip joint. In some cases the parabolic curve of the superior branch of pubic bone is so severe that makes impossible long screws insertion without perforating the acetabulum. In this case a short screw is inserted which decreases biomechanical rigidity of fixation [16].

Open reduction and internal fixation of pubic rami fractures by plates requires extensive surgical exposure with blood loss which may result in severe complications like injury to femoral artery, vena and/or nerve [21].

To solve the existing problems the authors propose a simple, secure and minimally invasive technique to fix pubic rami fractures by interlocking nails. An arched shape of nail and its elasticity allows to insert the implant bypassing the acetabulum with any curvature type of pubic bone (cannulated screws fixation is deprived of such advantage). Fixation rigidity is ensured by three-point implant fixation: first point — at insertion site, second — at fracture site or at the isthmus, and third — at site where proximal part of the nail is wedged in the dense bone of supraacetabular area or rests on its wall. Nail interlocking by two screws creates additional rotational and axial implant stability inside the medullary cavity.

The designed method of pubic rami fracture fixation allows to perform closed reduction of fragments on the nail similarly to joystick. Minimal blood loss, fast implant insertion without subsequent removal are the advantages of proposed technique. Besides, the presented method provides for stabilization of anterior half-ring in presence of colostomy, epicycstostomy and drainages in the

anterior abdominal wall without any inflammatory complications.

The described method allows to almost immediately relieve pain syndrome at the site of pubic fracture and mobilize the patient in maximally short term thanks to secure fragments fixation.

The authors did not find any literature on use of the same or similar surgical technique, which doesn't allow to compare the treatment outcomes to other data.

Proposed technique of internal fixation for pubic rami fractures is minimally invasive with minimal blood loss and low rate of possible inflammation in postoperative period. Interlocking nail allows retrograde fixation of fragments in all zone according to Nakatani from one approach without risk of hip joint injury. Minimally invasive technique can be applied in patients with wounds of anterior abdominal wall, for example, after laparotomy, in patients with colostomy, epicycstostomy and various drainages in this area. Besides, the described method provides for healing of pubic rami fractures at the same rate as the standard methods and to obtain good functional outcomes in early terms. Fixation has the sufficient biomechanical stability to enable full support ability of the lower leg immediately after the surgery. Interlocking nail fixation is the definitive fixation method which doesn't need mandatory implant removal after confirmed healing.

The present research has limitations due to a relatively small number of patients and short follow up terms. Further accumulation of clinical data and statistical analysis of outcomes is required. The authors believe that the proposed treatment option has promising outlooks due to its advantages: simple surgical technique, minimal invasive procedure and high fixation properties.

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INFORMATION ABOUT AUTHORS:

Pavel A. Ivanov – Dr. Sci. (Med.), professor, head of the Polytrauma Department, Sklifosovsky Clinical and Research Institute for Emergency Care, Moscow, Russian Federation

Nikita N. Zadneprovskiy – research associate, Polytrauma Department, Sklifosovsky Clinical and Research Institute for Emergency Care, Moscow, Russian Federation

Alexander V. Nevedrov – Cand. Sci. (Med.), research associate, Polytrauma Department, Sklifosovsky Clinical and Research Institute for Emergency Care, Moscow, Russian Federation

Vsevolod O. Kalensky – research associate, Polytrauma Department, Sklifosovsky Clinical and Research Institute for Emergency Care, Moscow, Russian Federation