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Superior pubic ramus fixation with titanium elastic nails-surgical technique

Fijación de la rama superior del pubis con clavos elásticos de titanio-técnica quirúrgica

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ABSTRACT. Superior pubic rami fractures are commonly associated with a posterior pelvic ring disruption. It has been shown that fixing both the anterior pelvic arch and the posterior ring increases stability and enhances clinical results. Several techniques for fixing the superior pubic rami exist, and multiple studies showed that minimally invasive methods decrease wound-related complications, with the advantage of preserving soft tissues. We describe a surgical procedure to treat simple pubic rami fractures associated with posterior pelvic ring disruptions by placing an intramedullary elastic titanium nail (TEN). We propose this technique as an alternative fixation method for superior pubic rami fractures.

Keywords: pelvic trauma, pubic rami, elastic titanium nail, minimally invasive surgery.

RESUMEN. Las fracturas de la rama superior del pubis se asocian con frecuencia a una alteración del anillo pélvico posterior. Se ha demostrado que la fijación tanto del arco pélvico anterior como del anillo posterior aumenta la estabilidad y mejora los resultados clínicos. Existen varias técnicas para fijar la rama superior del pubis, y múltiples estudios han demostrado que los métodos mínimamente invasivos disminuyen las complicaciones relacionadas con la herida, con la ventaja de preservar los tejidos blandos. Describimos un procedimiento quirúrgico para tratar fracturas simples de la rama púbica asociadas a disrupciones del anillo pélvico posterior mediante la colocación de un clavo intramedular elástico de titanio (TEN). Proponemos esta técnica como método de fijación alternativo para las fracturas superiores de la rama púbica.

Palabras clave: traumatismo pélvico, rama púbica, clavo elástico de titanio, cirugía mínimamente invasiva.

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Introduction

Pubic rami fractures are uncommon injuries, with two incidence peaks: in young patients due to high energy mechanisms, and fragility fractures in the elderly. The reported incidence is 6.9/100,000 per year in the general population and 25.6/100,000 per year in the over 60 years of age population.[1] They can present as an isolated lesion but are usually associated with posterior pelvic ring injury in 54-97% of cases.[2,3]

Nakatani proposed a location-based classification system for these fractures, using a simple pelvic X-ray, dividing the superior pubic ramus into three zones. Zone I is medial to the obturator foramen; zone III is lateral to the obturator foramen and Zone II lies between both zones.[4]

Isolated pubic rami fractures are usually considered stable and can be managed conservatively. In cases associated with posterior pelvic ring disruption or a considerable amount of displacement, it has been shown that anterior rig fixation increases pelvic stability, and surgical treatment is indicated.[5,6,7,8]

Several internal fixation methods have been described, each with its advantages and disadvantages. Anatomic and reconstruction plates are widely utilized, but they require an open approach that allows for direct fracture reduction and stable fixation, or a mini-open approach that also transects the surrounding soft tissue, thus most of the complication rates are associated with the surgical approach or implant failure.[8,9]

Percutaneous methods have gained much interest lately. Intramedullary cannulated screws are the most used implant, they have good results and can be placed in an antegrade or retrograde manner depending on fracture location. One of the main complications reported with this method is an invasion of the hip joint space, which can lead to articular damage and posttraumatic arthritis, Gras et al. reported 6% screw misplacement in a study of 29 screws.[10] The other most frequently reported complication is implant failure; with screw disengagement in 8 to 15% of patients. This fixation method is also technically demanding and requires closed reduction maneuvers and expertise due to its proximity to neurovascular structures.[4,7]

There are other minimally invasive intramedullary methods such as the photodynamic stabilization system described by Stavros Oikonomidis.[11] The Pelvic Bridge described by Cole uses plate rod constructs.[12] The INFIX described by Vaidya is a subcutaneous internal fixator, and other variations have been described, but are not widely available in most institutions.[13,14]

According to biomechanical and clinical studies, most methods can enhance pelvic stability in combined lesions and achieve fracture healing. The indications for using one or another are based primarily on the pattern of the fracture and depend on the surgeon's preference and available resources.[9,14,15]

We propose an alternative simple fixation method for pubic ramus fractures with titanium elastic nails, as described below.

Table 1: Characteristics of the sample.

Characteristic	Value
Age	35 (6.16)
Sex, (%)	
Female	5 (83.3)
Male	1 (16.7)
ISS	31.5 (16, 18-48)

ISS = injury severity score.
Values are: Mean (standard deviation), absolute frequency (percentage), median (interquartile range, min-max)

Our objective is to describe the surgical technique used by us to fix anterior pubic rami fractures with TEN and illustrate the functional and radiographic results of a case series treated in our institution.

Material and methods

We retrospectively reviewed the medical records of all patients with pelvic fractures treated between January 2019 and January 2020 at our institution, retrieving clinical data and imaging studies up to their last follow-up.

We found six adult patients who were admitted with a pelvic lesion, Tile-type B or C, presenting with pubic rami fracture, and who underwent anterior fixation with TENs and posterior pelvic ring fixation with other methods and completed at least one year of follow-up.

Numeric variables with a normal distribution (tested with the Shapiro-Wilk test), are reported as mean (standard deviation), parametric variables (ISS), are reported as median (interquartile range, minimum-maximum); categorical variables are described as absolute frequency (percentage) *(Table 1)*.

Surgical technique

Surgery is usually performed under general anesthesia or regional spinal block, in a supine position, over a radiolucent table. Under 2D fluoroscopy guidance, using the traditional inlet and outlet projections, with the C-arm positioned across from the surgeon on the fracture side. With the use of fluoroscopy, the pubic tubercle is identified, and a 15mm skin incision is made. The exact insertion point can vary depending on the fracture location and shape of the pubic ramus, but we recommend using the anterior pubic tubercle as the insertion point. The nail diameters are about two-thirds of the medullary isthmus, the size of the nail is measured using this formula = 0.4 × canal diameter in mm.

The anterior cortical bone is opened with an awl, oriented at 45º, at the determined nail entry point, the awl is inserted perpendicular to the cortex and the angle is gradually lowered, entering the medullary canal with rotating movements. The elastic flexible nails are pre-bent and inserted into the medullary canal. This elastic deformation within the medullary

canal creates a bending moment within the long bone that is not rigid but is stable enough to reduce and fix the fracture. A titanium elastic nail is inserted into the pubic ramus under fluoroscopy control, with the nail tip at right angles to the upper cortex of the pubic ramus. The nail is rotated 180° with the inserter and the nail tip is aligned with the axis of the medullary canal. Nail curvature should be oriented to facilitate reduction, orienting the nail tip into the proximal fracture site and advanced manually through the rami canals up to the supra-acetabular zone in type II fractures, and into the posterior column in type III fractures. The nail end is cut approximately 5 mm from the cortex and impacted into the pubic ramus to the final position. No caps are inserted *(Figure 1)*.

Inlet, outlet, obturator, and iliac views are used as X-ray control views during the procedure to assess the correct position of the implant *(Figure 2)*. The nail is positioned through the anterior acetabular column. The incision is closed in the usual manner. Mobilization can be started immediately and partial weight bearing is started as tolerated. Full weight bearing is allowed at 10-12 weeks postoperatively.

Case illustration

Our series comprises six patients treated at a level 1 trauma center by a single pelvic surgeon, all patients were

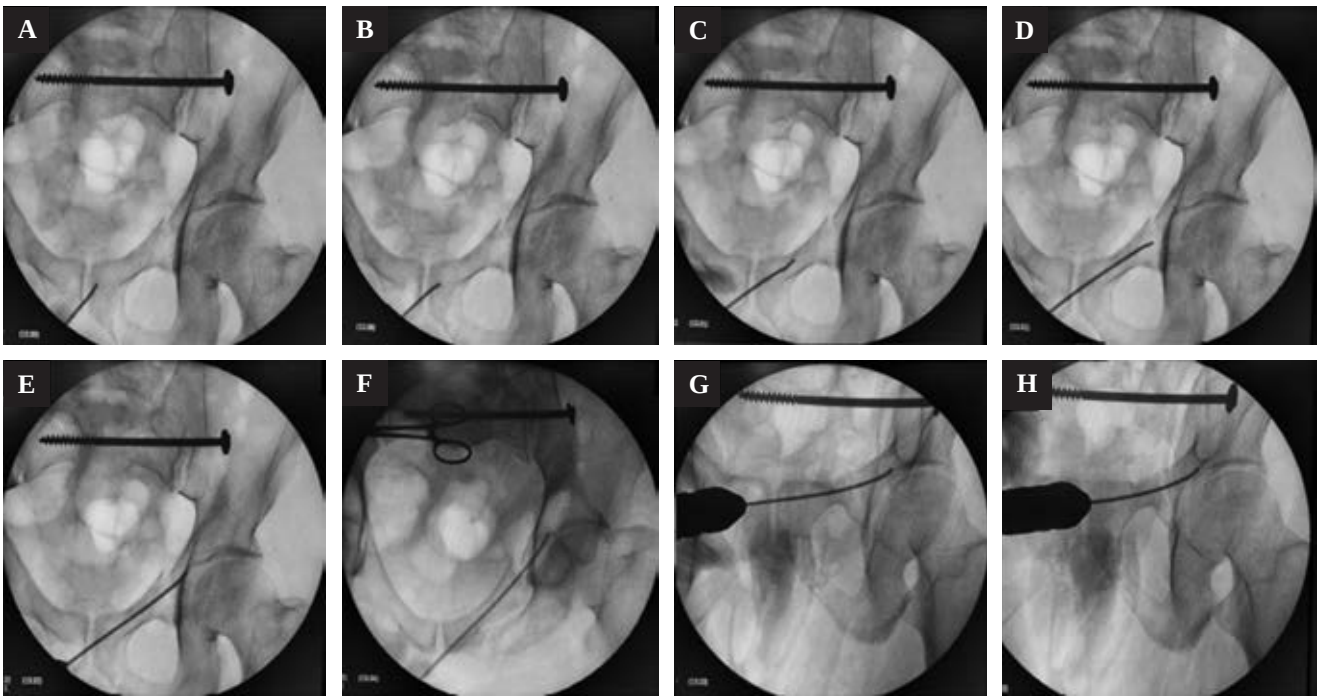

Figure 1: Implant placement sequence: **A)** Entry point. **B-D)** Implant placement through the entry point. **E-H)** Reduction and fracture fixation with the elastic nail into the supraacetabular area.

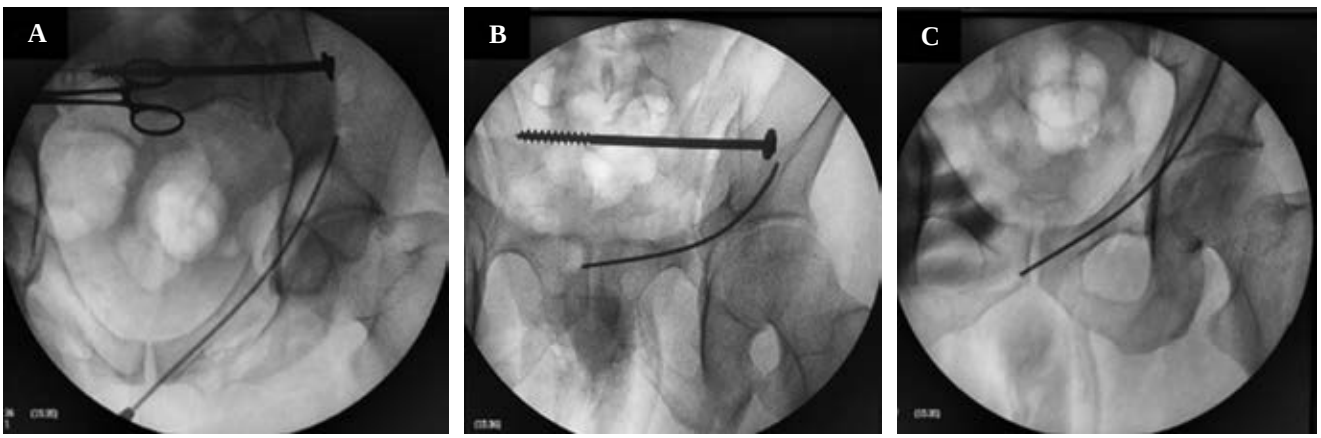

Figure 2: X-ray control views. **A)** Inlet. **B)** Outlet. **C)** Anteroposterior.

Table 2: Patients.

Patient	Gender	Age	Young-Burges	Tile	Nakatani	Injury Severity Score	Associated lesions	Management
1	Female	37	Lateral compression	B2	II	26	Femur fracture, degloving of the lower leg.	EF
2	Female	21	Lateral compression	B2	II	34	BCT + HT	DF
3	Female	34	Lateral compression	B3	II	18	Acetabular fracture dislocation + tibial intercondylar tubercle fracture	DF
4	Female	37	Mixed	C	II	48	BCT + HT	DF + EF + ICU
5	Female	38	Lateral compression	B2	II y II	48	Exposed femoral shaft fracture + soft tissue lesion of the foot + HT	DF + EF+ ICU
6	Male	38	Lateral compression	B2	III	29	Exposed tibial shaft fracture + BCT + HT	DF + EF

EF = external fixator. BCT = blunt chest trauma. HT = head trauma. DF = definitive fixation. ICU = intensive care unit.

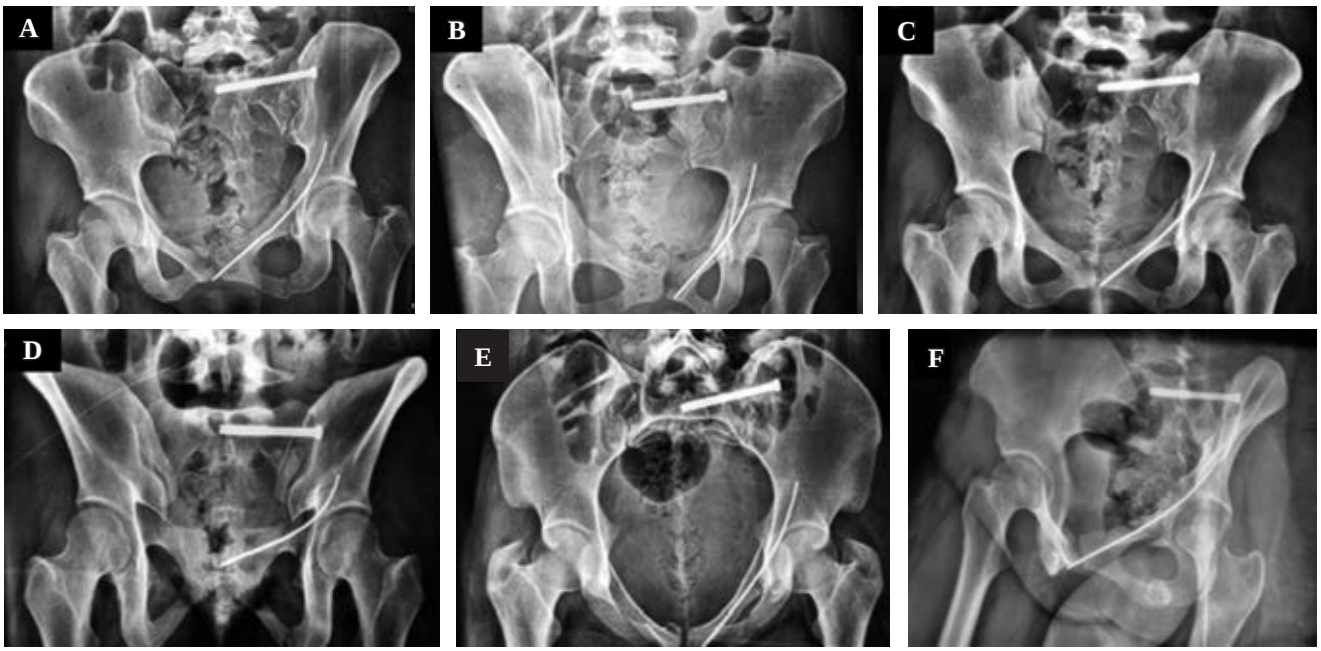

Figure 3: A-E) Immediate postoperative X-ray series. **F)** Obturator oblique X-ray at one-year follow-up.

admitted through the emergency room and underwent standard ATLS-based protocols *(Table 2)*.

Patient one was a 37-year-old female with a Tile B2.1, Nakatani II pelvic injury, associated with a sub trochanteric open femur fracture and soft tissue de-gloving injury in the lower leg. She underwent immediate external fixation and debridement. Two weeks later she underwent definitive surgery with placement of a posterior iliosacral screw, anterior pubic ramus fixation with two 3.0 mm TEN (the fracture was deemed unstable after placement of a single nail), and intramedullary nail fixation for the femur. She achieved radiographic evidence of pelvic fracture healing 12 weeks after surgery. Rehabilitation and weight bearing were delayed because a femoral fracture nonunion required revision surgery and eventually healed 18 months after the initial injury. No other complications were observed.

Patient two was a 21-year-old female who suffered a lateral compression injury resulting in a Tile B2 fracture, as well as three rib fractures and a hemothorax. She was stable at arrival and underwent internal fixation with a percutaneous iliosacral screw and one 2.5 mm TEN for pubic ramus fixation. Complete fracture healing and complete clinical recovery were observed at 12 weeks follow up and no complications were reported *(Figure 3)*.

Patient three was a 34-year-old female who suffered a parachute fall, with an anteroposterior compression injury resulting in a tile C fracture pattern, associated with acetabular and tibial spine fractures. She was stable at arrival and underwent internal fixation with a posterior sacroiliac screw, a reconstruction plate for the left acetabular fracture, and one anterior 2.5 mm TEN for the right ramus. All fractures healed uneventfully, and she achieved full weight bearing at 12 weeks follow-up *(Figure 4)*.

Patient four was a 37-year-old female with a tile B2 unstable fracture associated with severe closed chest trauma, rib fractures, and head trauma. She underwent initial external fixation, chest decompression, and stabilization in the ICU. Posterior definitive fixation was performed with a posterior bilateral percutaneous sacroiliac screw and anterior 2.5 mm TEN fixations. She achieved fracture consolidation and returned to her daily activities at three monthly follow-ups. No complications were reported.

Patient five was a 38-year-old female who suffered a lateral compression injury, which caused a tile B3 fracture associated with severe head trauma, open femoral fracture, and metatarsal open fracture. She was hemodynamically unstable at arrival, and she underwent definitive fixation for the pelvis with a posterior sacroiliac screw and two anterior 3.0 TENs for the right ramus, and one 3.0 TEN for the left ramus, plus external fixation and debridement of the femur and metatarsal fractures, ICU care and later definitive intramedullary fixation. She was discharged after two months, with evidence of pelvic fracture healing, but suffered severe neurological sequelae preventing her from fully recovering.

Patient six was a 38-year-old male with a tile B3 lateral compression injury associated with severe closed chest trauma and an open tibial shaft fracture. Internal fixation was done with a posterior sacroiliac screw and anterior 2.5 mm TEN for the ramus fracture, initial debridement, and external fixation of the tibia which was later converted to plate fixation. Full weight bearing was delayed until twelve weeks. The patient recovered fully and was able to return to daily activities.

Discussion

Titanium elastic nails (TENs) are a widely available and low-cost implant, mainly used to treat pediatric fractures, although seldom used in the adult population, they have shown good results in the treatment of mid-clavicle, humerus, and radial shaft fractures. Their use has multiple advantages, since they avoid extensive exposure, require only 2D fluoroscopy guidance, can be placed in patients with soft tissue compromise, and can facilitate closed reduction.[16,17,18]

To our knowledge, no available studies have described the use of TENs in pubic rami fixation. Two biomechanical finite element analyses analyzed them. The first one by Narucha in 2019 compares three fixation methods for a type II Nakatani fracture; a 3.5 mm reconstruction plate, a 6.5 mm intramedullary cannulated screw, and a 4.0 titanium elastic nail.[19] The second study published by Yong-Ze Zheng et al. in 2021 compared the stability between a single elastic intramedullary nail with intramedullary cannulated screw fixation and a double elastic nail model. They showed the elastic nail model had a better and larger stress distribution, and there was no significant difference between the cannulated screw and the double elastic nail fixation, although the single elastic nail did show less stability than the latter.[20]

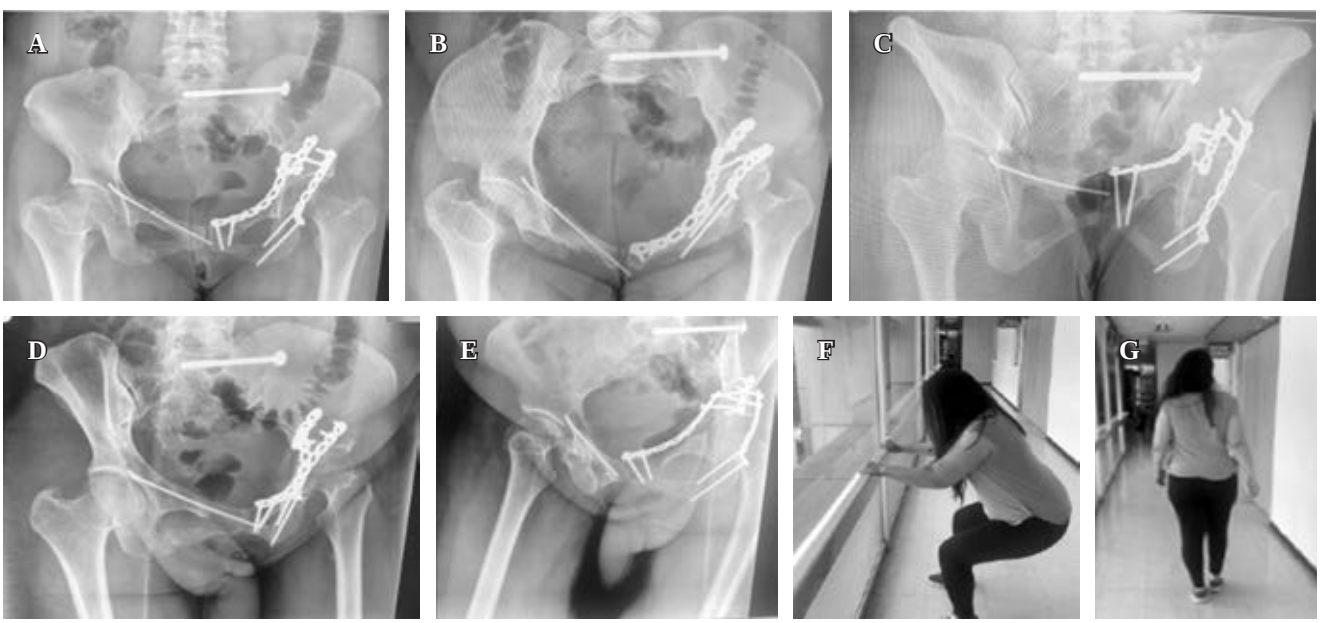

Figure 4: A-E) One-year follow-up X-ray series of patient n. 3 shows complete fracture healing of the right pubic ramus fixed with a TEN. **F-G)** Clinical photograph of the patient walking and full hip range of motion.

Because of the anatomical three-dimensional curved nature of the pubic ramus, in addition to its variable intramedullary canal which has an elliptic shape close to the symphysis, and transitions to a triangular, then ovoid and again triangular shape as it approaches the acetabular region, the placement of straight and rigid implants, such as intramedullary screws can be quite difficult.[20]

Therefore, we hypothesized and have successfully used elastic titanium nails as an easier treatment option for pubic ramus fractures associated with partial posterior ring disruption. This enabled us to reduce our surgical time and bleeding and use a complete percutaneous approach for both the rear and anterior pelvic ring fixation.

Intramedullary elastic fixation is based on three main principles first described by Lascombe: soft tissue and biologic preservation that maintains the osteogenic potential of the hematoma and is not too aggressive to the medullary vessels; elimination of deleterious stress with stability but no rigidity, allowing enough movement to promote callus formation and faster healing; and preservation of tendon and muscle activity to improve the morphology of callus.[21] Their mechanical properties provide stable intramedullary splinting, with a wide contact surface and tensile force that reduces stress concentration while loading, this enables fracture healing and reduces pain, and allows for early mobilization.[22]

During the development of this fixation method, we realized that the greater the nail length, the greater stabilization was achieved. Thus, placement through the supraacetabular area into the de posterior column is recommended independently of the fracture location. This enables a greater contact surface and better load distribution.

Regarding the width of the implant, we used 2.5 and 3.0 mm implants, with no clinical difference observed between patients. No implant-related complications were reported at a mean follow-up of 18 months.

It has been shown in a biomechanical study[23] that increasing the thickness and length of the implant in elastic intramedullary fixation increases stiffness becoming more stable, nevertheless, this has not been translated to a clinical significance. We observed that nails thinner than 2.0 did not provide stability to the fracture, thicker nails increase rigidity but can be more difficult to place. Two nails must be placed in cases where stability was not obtained with one nail placement.

Conclusions

When fixing unstable pelvis fractures, a reduction of surgical time and bleeding, as well as minimizing exposure, are valuable elements to achieve. Authors recommend this fixation method for simple Nakatani Zone II and III superior rami fractures, for unilateral fixation, associated with a posterior arc disruption, for superior pubic rami fractures associated with acetabular contralateral fracture, bilateral pubic rami fractures when the most unstable ramus is previously fixated whit another method (plate or screw) and fixation for pubic rami associated to a spinopelvic fixation. Relative contraindications are zone I fractures, comminuted fractures, and open fractures. The further away the fracture is from the pubic symphysis greater stability is achieved. We do not recommend this implant to achieve stability when complete disruption of the posterior arch is presented, and no other methods of fixations complete the fixation or as a single method of fixation.

The main limitations of this study were our small sample size, the relative homogeneity between patients, and the lack of randomization. Most of our patients were polytraumatized so rehabilitation and recovery were influenced by the associated injuries as well, although no complications were attributable to the rami fractures. Further studies must be conducted to determine the safety and efficacy of this technique in comparison to the standard methods.

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Conflicts of interest: the authors have no competing interests to declare.