Original Article
Modified minimally invasive percutaneous bridge fixation technique for the treatment of unstable anterior pelvic ring fractures in males

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Abstract: Objective: The objective of this study was to introduce an improved minimally invasive percutaneous bridge fixation technique. After revealing the spermatic cord, the plate was inserted with the spermatic cord placed above the plate to avoid damaging the spermatic cord. Methods: The medical records and follow-up results of 10 male patients with unstable anterior pelvic ring fractures who underwent modified minimally invasive percutaneous bridging fixation technique from January 2015 to January 2018 were retrospectively analyzed. The evaluating indexes including operation time, blood loss, quality of reduction (Matta criteria) and complications were recorded. Results: The average operative time was 68.5 minutes (range, 50-120), and the average volume of intraoperative blood loss was 78.0 ml (range, 40-200). The quality of reduction was evaluated using the Matta criteria, as follows: excellent in 7 cases, good in 2 cases, fair in 0 cases, and poor in 1 case. The rate of excellent and good reduction was 90%. No instances of iatrogenic spermatic cord injury or inguinal hernia occurred. Conclusion: The modified minimally invasive percutaneous bridge fixation technique avoids iatrogenic spermatic cord injury and offers a safe alternative method for the treatment of anterior pelvic ring fractures in males.

Keywords: Pelvic fracture, bridge fixation, spermatic cord

Introduction
Pelvic fracture is a common fracture with a high incidence of widespread skeletal damage of 3% [1]. Pelvic ring injury is the result of high-energy trauma and is usually an unstable fracture [2-4]. Tile [5] confirmed that the anterior and posterior pelvic structures accounted for 40% and 60% of pelvic stabilization, respectively. To better stabilize pelvic fractures, it is necessary to combine anterior and posterior fixation.

Common methods for treating anterior pelvic ring fractures consist of external and internal fixation. The advantages of external fixation are little trauma and simple operation, but complications, such as pin tract infection, aseptic loosening, and local ulceration, can affect hip joint mobility and require inconvenient nursing care [6]. Internal fixation has become the preferred method for treating unstable pelvic fractures. However, the complex anatomical structures of the region, including important blood vessels, nerves, round ligaments, and the spermatic cord in males, are prone to iatrogenic injury and can lead to serious surgical complications [7].

In recent years, with technological developments and surgical innovation minimally invasive percutaneous internal fixation, which is associated with less trauma, reduced bleeding, easier execution, fewer complications and benefits to patient recovery, has become the mainstream method for the treatment of anterior pelvic ring fractures.

In 2012, Cole and colleagues were the first to report the minimally invasive percutaneous bridge fixation technique for treatment of the anterior pelvic ring [8]. The technique causes little trauma, is easy to perform and has few complications. However, with this technique, the spermatic cord is located under the plate,
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Table 1. Patient characteristics

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Mechanism of injury</th>
<th>Tile type</th>
<th>Concomitant injuries</th>
<th>Operative time (min)</th>
<th>Blood loss (mL)</th>
<th>Matta criteria</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>27</td>
<td>Crush</td>
<td>B2</td>
<td>GUSI</td>
<td>75</td>
<td>100</td>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>53</td>
<td>Fall</td>
<td>B2</td>
<td>LSPI</td>
<td>60</td>
<td>55</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>36</td>
<td>Fall</td>
<td>C1</td>
<td>LSPI</td>
<td>55</td>
<td>55</td>
<td>Excellent</td>
<td>PE</td>
</tr>
<tr>
<td>4</td>
<td>34</td>
<td>Fall</td>
<td>B1</td>
<td>Chest injury</td>
<td>80</td>
<td>90</td>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>57</td>
<td>Fall</td>
<td>B1</td>
<td>Head injury</td>
<td>50</td>
<td>70</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>49</td>
<td>Fall</td>
<td>B2</td>
<td>Head injury</td>
<td>60</td>
<td>65</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>47</td>
<td>Fall</td>
<td>B2</td>
<td>None</td>
<td>65</td>
<td>40</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>30</td>
<td>Fall</td>
<td>B2</td>
<td>Head injury</td>
<td>65</td>
<td>45</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>40</td>
<td>Crush</td>
<td>C1</td>
<td>Chest injury</td>
<td>55</td>
<td>60</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>69</td>
<td>Traffic</td>
<td>C1</td>
<td>Abdominal injury</td>
<td>120</td>
<td>200</td>
<td>Poor</td>
<td>DVT, UTI</td>
</tr>
</tbody>
</table>

GUSI, genitourinary system injury; LLF, limb or lumbar fracture; LSPI, lumbosacral plexus injury; PE, pulmonary embolism; DVT, deep vein thrombosis; UTI, urinary tract infection.

and because the anatomy of the inguinal canal and the spermatic cord is complicated and the spermatic cord is not fully revealed, there is the theoretical possibility of damage [9].

The purpose of this study was to introduce an improved surgical technique whereby after fully revealing the spermatic cord, the plate is inserted with the spermatic cord above the plate to avoid damaging the spermatic cord.

Materials and methods

A retrospective analysis was performed to treat unstable anterior pelvic ring fractures treated from January 2015 to January 2018. Cases were included in the analysis: (1) patients with a Marvin Tile classification [5] of type B or C for unstable pelvic fractures and involvement of the anterior annulus; (2) patients undergoing treatment with the modified minimally invasive percutaneous bridge fixation technique; and (3) male patients.

Throughout the study, a total of 15 patients underwent minimally invasive percutaneous bridge fixation of the anterior pelvic ring. Five of the patients were women. In all, 10 patients (Table 1) met the inclusion criteria.

The average age of the 10 male patients was 44.2 years (range, 27-69). The mechanism of injury was as follows: fall from a height, 7 cases; crush injury, 2 cases; and traffic accident, 1 case. According to the Tile classification, there were 2 cases of B1, 5 cases of B2, and 3 cases of C1 fractures. Among them, the fractures were combined with other injuries in 9 cases, including head injury in 2 cases, chest injury in 3 cases, abdominal injury in 1 case, genitourinary system injury in 2 cases, lumbosacral plexus injury in 2 cases, and limb or lumbar fracture in 5 cases.
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Figure 1. Schematic drawing showing the plate under the spermatic cord to prevent compression of the spermatic cord.

Surgical technique

General anesthesia was used, and the anterior ring fracture was treated with the patient in the supine position. The anterior superior iliac spine (ASIS) was exposed obliquely by an incision approximately 3-5 cm in length. The pubic symphysis was exposed by a transverse incision approximately 6-8 cm in length. The ASIS incision was separated downward to the aponeurosis of the external oblique muscle. A periosteal screwdriver was used for blunt tissue dissection, and a subcutaneous tunnel was carefully created by hand in the superficial layer of the external oblique aponeurosis. The rectus abdominis at the pubic symphysis incision was separated. The traditional method involves inserting the plate into the subcutaneous tunnel and then inserting the screw without dissecting the spermatic cord and with the spermatic cord located under the plate. In the operation, the shallow ring of the inguinal canal was identified and the spermatic cord was dissected by gently pulling it with a rubber tube. Next, the plate was inserted and the spermatic cord was placed above the plate, screwed in the two ends of the plate with 2-3 screws, and then repaired the shallow ring of the inguinal canal (Figures 1 and 2). Then, drainage was placed, and the wound was sutured layer by layer.

Outcome evaluation indexes

Outcome evaluation indexes, including the operative time, blood loss, quality of reduction (Matta criteria) and complications, were recorded.

The Matta evaluation criteria [10] were used to evaluate the quality of pelvic anterior ring fracture reduction on X-ray films, with a fracture separation displacement < 4 mm considered excellent, 4-10 mm considered good, 10-20 mm considered fair, and > 20 mm considered poor.

Particular complications of our technique included iatrogenic spermatic cord injury and inguinal hernia. Other common complications included wound infection, nonunion, and fixation failure. Bed-related complications included urinary tract infection, deep vein thrombosis, and pulmonary embolism.

Statistical analysis

All data were analyzed using SPSS v. 19.0 software (Chicago, IL, USA). The collected data are presented as the mean and SD.

Results

All 10 patients underwent treatment by anterior and posterior ring fixation. Unilateral anterior ring fixation was applied in eight patients, and bilateral fixation was applied in two patients. The average operative time was 68.5 minutes (range, 50-120), and the average volume of intraoperative blood loss was 78.0 ml (range, 40-200).

The quality of reduction was evaluated using the Matta criteria, as follows: excellent in 7 cases, good in 2 cases, fair in 0 cases, and poor in 1 case. The rate of excellent and good reduction was 90%. The only case of poor reduction was due to poor reduction of the posterior pelvic ring fracture, which is irrelevant to our technique.

All patients were followed for a mean duration of 12.1 months (range, 9-19). There were no instances of wound infection, nonunion or fixation failure.

Complications of the technique, i.e., iatrogenic spermatic cord injury and inguinal hernia, did not occur. Only one patient developed pulmonary embolism, and one patient developed deep vein thrombosis and urinary tract infection.
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Discussion

Minimally invasive percutaneous internal fixation, which offers less trauma, easier execution and fewer complications, has become the mainstream method for the treatment of anterior pelvic ring fractures [11]. Percutaneous pelvic anterior ring fixation techniques include fixation using percutaneous pubic screws [12], a percutaneous pelvic internal fixator (INFIX) [13, 14], and a percutaneous bridge [8]. Percutaneous pubic screw fixation carries the risk of internal fixation failure or injury to the adjacent important structures, such as the spermatic cord, nerves [15] and pelvic organs. Due to the complicated anatomy of the pelvis, it is possible to enter the hip joint when the pubic screw is inserted. Although the application of navigation technology can reduce certain risks, the requirements for the operator, hardware and facilities are very high. Moreover, this surgical procedure cannot be applied in patients with an unsatisfactory closed reduction, patients who are overweight or underweight, or patients with excessive pubic curvature. Studies in the literature on the INFIX device have reported high rates of complications [16], such as lateral femoral cutaneous nerve injury, femoral nerve palsy [17], and heterotopic ossification. Thus, care should be taken when treating anterior pelvic ring fractures with the INFIX device. In contrast, percutaneous bridge fixation has the advantages of a short learning curve, low operational difficulty, low requirements for hardware and facilities, less intraoperative radiation exposure, and a low complication rate.

Due to the lack of direct visualization with the minimally invasive percutaneous bridge fixation technique, some neurovascular structures, such as the lateral femoral cutaneous nerve, femoral artery and vein, femoral nerve and the round ligament in females or spermatic cord in males, are theoretically at risk of being injured. Spermatic cord injury is the most catastrophic iatrogenic neurovascular complication that could occur during the surgical treatment of anterior ring fractures. The spermatic cord contains testicular arteries, a venous plexus, the vas deferens and their associated blood vessels, nerves and lymphatic vessels [18, 19]. A previous study reported that the average distance of the spermatic cord from the bridge plate was only 0.4 cm [20]. Thus, slight error could cause the plate to compress the spermatic cord, causing testicular necrosis in severe cases.

The anatomy of the inguinal canal and spermatic cord is complex, and there are anatomical variations. The most common anatomical variations include inguinal hernia and spermatic lipoma [21-25]. Furthermore, fracture displace-
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ment can result in changes in the position of the spermatic cord. Sometimes, the steel plate could also compress the spermatic cord due to inappropriate shaping. If the spermatic cord is not fully revealed, and the steel plate is blindly placed above the spermatic cord, the spermatic cord may be damaged. Therefore, Reza et al. proposed routinely exposing the spermatic cord in pelvic anterior ring surgery [15].

Hence, careful dissection of the superficial inguinal ring to expose the spermatic cord was performed. Then, the spermatic cord was gently retracted, and the plate was inserted with the spermatic cord above the plate to avoid damaging the spermatic cord. There were no cases of iatrogenic spermatic cord injury or inguinal hernia. Although the inguinal canal was dissected in the series, no instances of inguinal hernia occurred, possibly due to our meticulous dissection because of our awareness of this complication.

Although the results of this work are very good, our research also has shortcomings. First, few cases were included. Second, as this study was a case review, there was no control group. The results require further confirmation by a comparative study with a large sample size.

Conclusion

The need to dissect the spermatic cord in the series certainly prolonged the operative time and increased the volume of intraoperative blood loss. However, this technique prevents the possibility of the patient experiencing catastrophic complications.

A modified minimally invasive percutaneous bridge fixation technique avoids iatrogenic spermatic cord injury and thus offers a safe alternative method for the treatment of anterior pelvic ring fractures in males.

Disclosure of conflict of interest

None.

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