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Brief Report

Modified Tension Band Wiring Using Only Non-Absorbable Braided Polyblend Sutures for the Treatment of Patellar Fractures

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Abstract: Patellar fractures represent approximately 1% of all fractures and the pattern is influenced by the quality of the bone and the energy of the trauma. Transverse fractures are associated with extensor mechanism failure and interruption of joint congruence. Patellar fractures are generally fixed using tension band principles, through K-wires and metal cerclage. The tension band was conceived to transform the considerable tensile force applied to the patella into a compressive one to obtain a stable fixation. The use of metal implants might be associated with a significant discomfort, mostly related to the irritating action of K-wires and cerclage on the surrounding soft tissues, often leading to the need for implant removal. Therefore, we introduced an original technique for fix patellar fractures by using only a non-adsorbable braided polyblend suture. Postoperative care included progressive range of motion recovery using an articulated knee brace and a specific protocol. The suture-only tension band technique seems to be a useful technique in terms of complications and reoperation rate while allowing secure and early mobilization.

Keywords: patellar fractures; tension band; suture; FiberWire; non-absorbable; fixation

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1. Introduction

Patellar fractures represent 1% of all fractures [1,2]. Common fracture patterns are transverse, vertical and comminuted [3]. More commonly, patella fractures are related to a direct high-energy trauma (i.e., dashboard injuries), that typically leads to a two-fragments fracture with a transverse gap [2]. The occurrence of a transverse or a comminuted patellar fracture is associated with both a patellofemoral joint incongruency and quadricep impairment [2,3]. In these cases, surgery is the treatment of choice [2–5]. To achieve valuable outcomes and prevent both joint stiffness and pain, stable fixation and early mobilization are both required [2]. These objectives might be very difficult to obtain, considering the incredible tensile forces acting on the patella that could easily lead to a secondary fracture displacement [3]. The tension band technique was specifically conceived to overcome this problem, exploiting its ability to convert the tensile forces into compressive ones during muscle contraction and weight bearing [1,4]. Different surgical techniques have been proposed to place the tension band on the patella [1]. The most common is based on the use of Kirschner wires (K-wires) longitudinally drilled into the patella, and on an 18-gauge stainless steel wire with a figure-of-eight loop positioned over the anterior side of the patella. However, the compression obtained by this kind of technique might be poor especially in case of poor bone quality. Therefore, some authors preferred to use cannulated screws and/or different stainless steel loop configurations [2,5]. The overall complication rate of these techniques is still high (up to 60%), and most of the reported complications might be directly related to the metal wires (i.e., implant failure, postoperative pain and functional limitation caused by irritation of the surrounding soft tissues) [3,5–7]. For this reason a significant reoperation rate for implant removal had been reported [6–8]. Moreover, metal wire migration and debris related to the fatigue failure of the wires might lead to both local and systemic tissue damage [3,8–10]. To overcome the limitation of metal-wiring-based tension band techniques, some authors have proposed to fix patella fractures using non-absorbable sutures. The use of non-absorbable sutures presents several supposed advantages over metal wiring, including patient tolerability (no soft tissue irritation); a lower reoperation rate (no need for implant removal) and easier use (the suture adapts well to the patella reducing surgical time and tourniquet use) [5–7,11].

Moreover, several studies showed that the reinforced braided polyblend sutures could be associated with both an adequate fracture stability and good clinical outcomes [7,8,11–14]. However, in clinical practice these sutures are mostly used just to replace the stainless steel wires to complete the figure-of-eight loop [4,5,11,14], and this kind of application does not completely avoid the risk of metal-related complications and the need for implant removal. Therefore, we conceived an original tension banding technique based on the use of only non-absorbable braided polyblend sutures to treat patellar fractures. The main aim of the present paper is to describe our technique. Moreover, to better analyze the outcomes of the conceived procedure, a retrospective evaluation of non-consecutive patients was conducted.

2. Materials and Methods

2.1. Surgical Technique

Our surgical technique is based on the use of three No. 5 FiberWire® sutures (Arthrex, Naples, FL, USA). These sutures are non-absorbable and have a core of several small individual strands of biocompatible polyethylene covered with braided polyester suture material. For practical purposes, we describe the technique as it should be conducted for transverse fractures; however, it could also be used in case of comminuted ones, provided that two major fragments are recognizable on the patellar articular surface, to provide a stable reduction with two-pointed reduction clamps.

The patient is placed in a supine position. Pre-operative antibiotics should be administered approximately 30 min before skin incision.

After tourniquet inflation, a midline longitudinal skin incision is performed. The articular surface is accessed through the fracture line and the incision of the retinacula, if needed. The fracture is then reduced using two reduction clamps and checked through appropriate fluoroscopy views (see Figures 1 and 2).

Two shuttle wires are then parallelly passed through the patella, from one pole to the other. The shuttle wires should be perpendicular to the fracture line (Figure 3a). For practical purposes, we prefer to pass the wires from the inferior to the superior pole. Two shuttle sutures (i.e., Vicryl n.0) are inserted into the parallel shuttle wires and connected to two No.5 FiberWires with a loop in their superior pole. The two FiberWires are passed throughout the patella, saving the loop positioned in the superior pole (Figure 3b). A noose is then created using the looped FiberWire at the superior pole, to prevent the subsequent inferior migration of the suture (Figure 3c). A third No. 5 FiberWire suture is then passed under the nooses (Figures 4 and 5), and the two parallel FiberWires are pulled down.

The third FiberWire is then used to draw the figure-of-eight loop on the non-articular surface of the patella (Figure 5c). The figure-of-eight FiberWire suture is manually tensioned and knotted on the superior pole of the patella (Figure 5d). The inferior parts of two parallel FiberWires are now tightened to the third FiberWire to fix the completed figure-of-eight loop (Figure 5 and Figure S1). The tension of the wires is manually performed, and, after removing the reduction clamps, the stability of the reduction and the adequate tension of the wires is evaluated (see Supplementary File Video S1). The residual parts of the three FiberWire sutures could be used to add a circumferential cerclage, if needed (i.e., comminuted fractures). Finally, the retinacula are sutured using absorbable sutures.

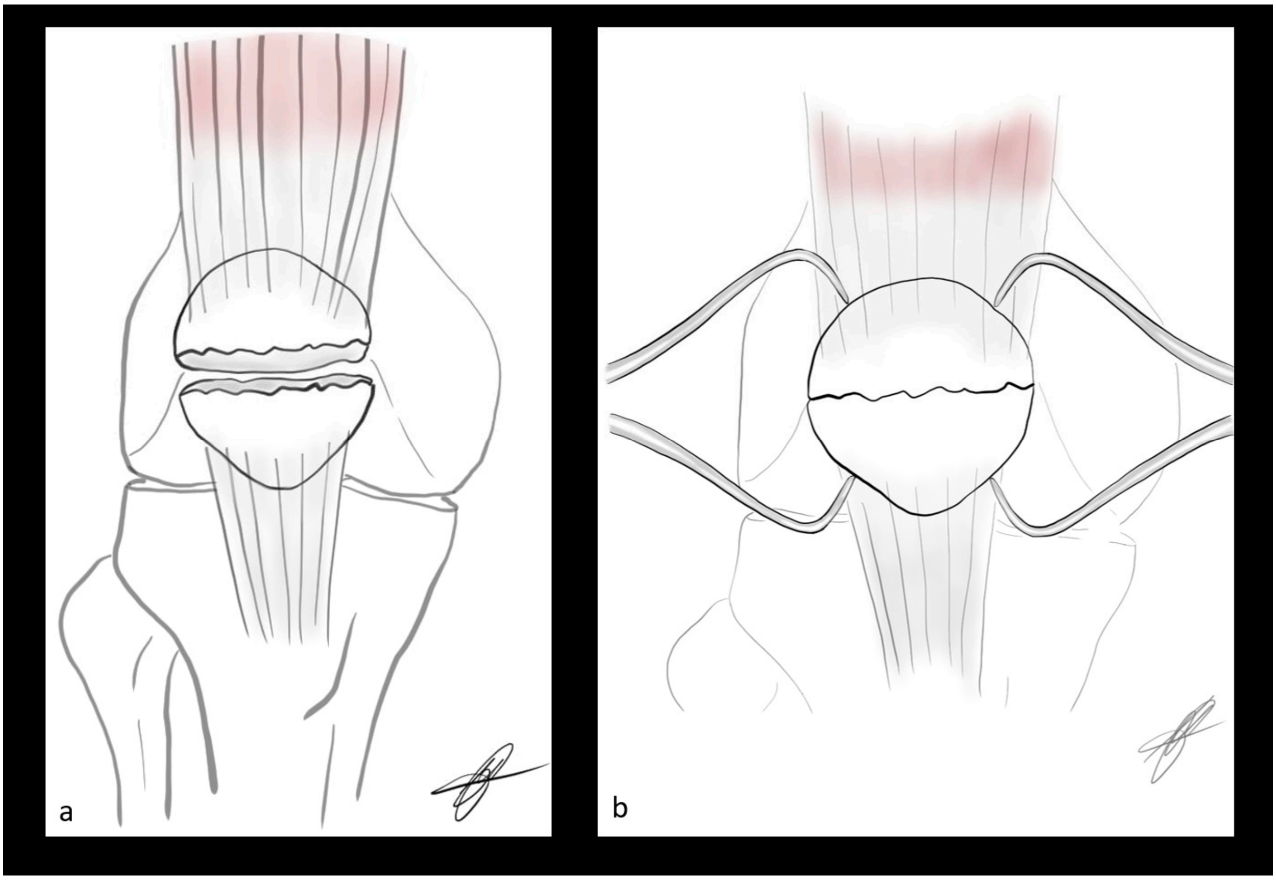

Figure 1. Drawing showing the start of the procedure before (**a**) and after (**b**) a perfect reduction of the patella using two reduction clamps.

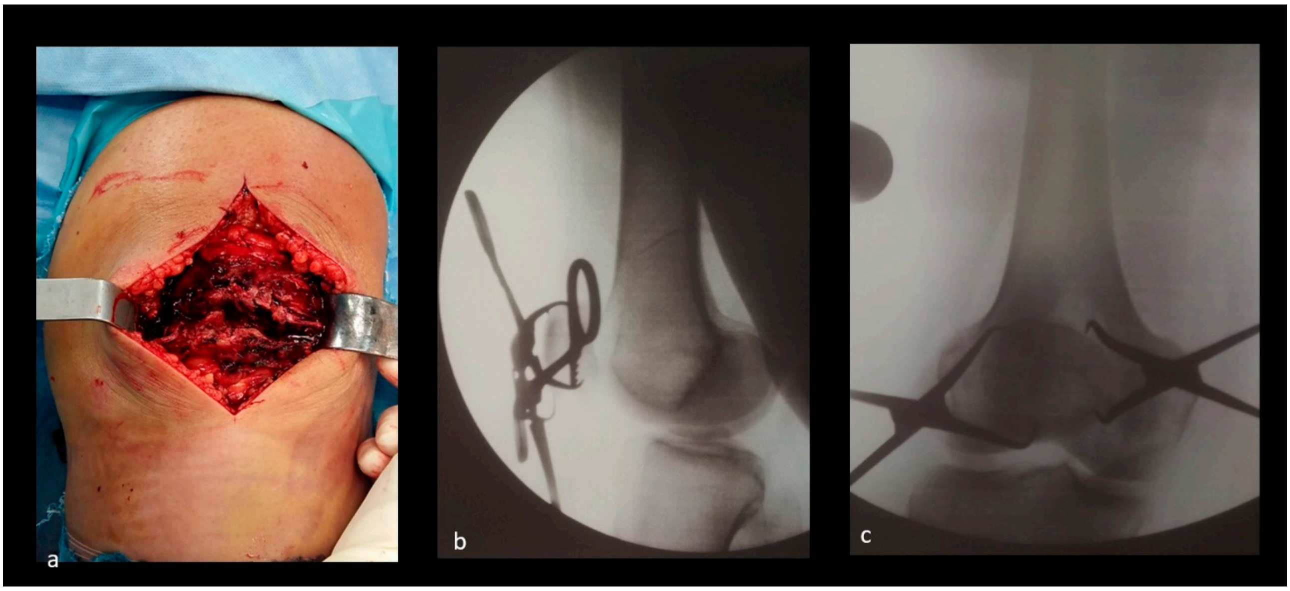

Figure 2. A clinical case of a transverse patellar fracture. (**a**) Intraoperative picture. (**b**,**c**) X-rays in medio-lateral and antero-posterior views, showing fracture reduction.

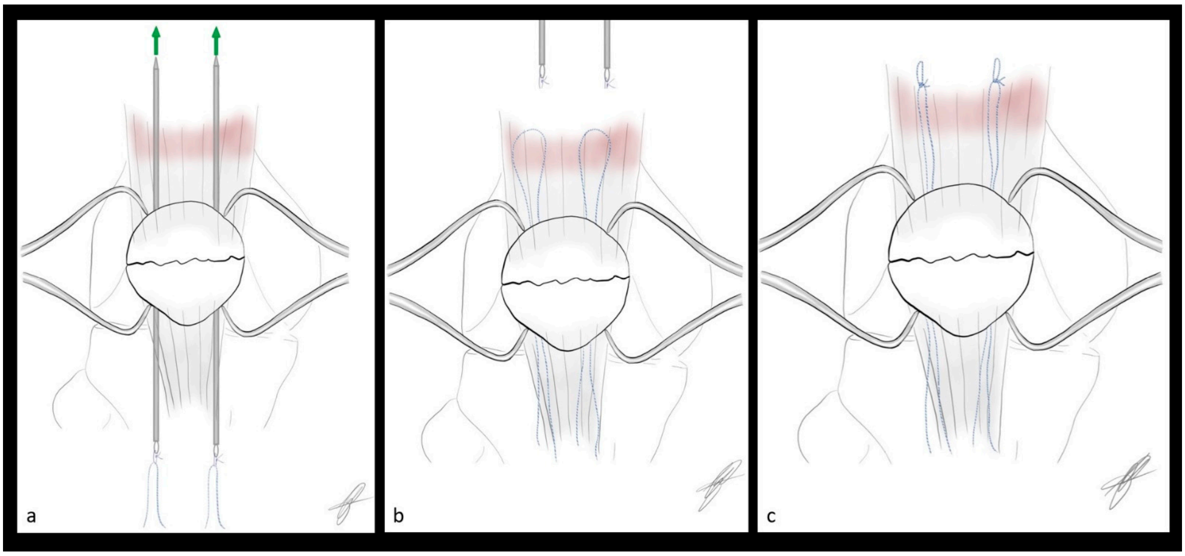

Figure 3. Drawing showing the initial phases of the tension banding creation. (**a**) Two shuttle wires are parallelly passed through the patella and then connected at the distal end with two shuttle sutures, each attached to a looped FiberWire (green arrows shows the direction of the shuttle wires); (**b**) No. 5 FiberWire sutures are passed through the patella maintaining the loop on their upper pole; (**c**) a noose is created on the upper pole to prevent the lower migration of the FiberWire sutures.

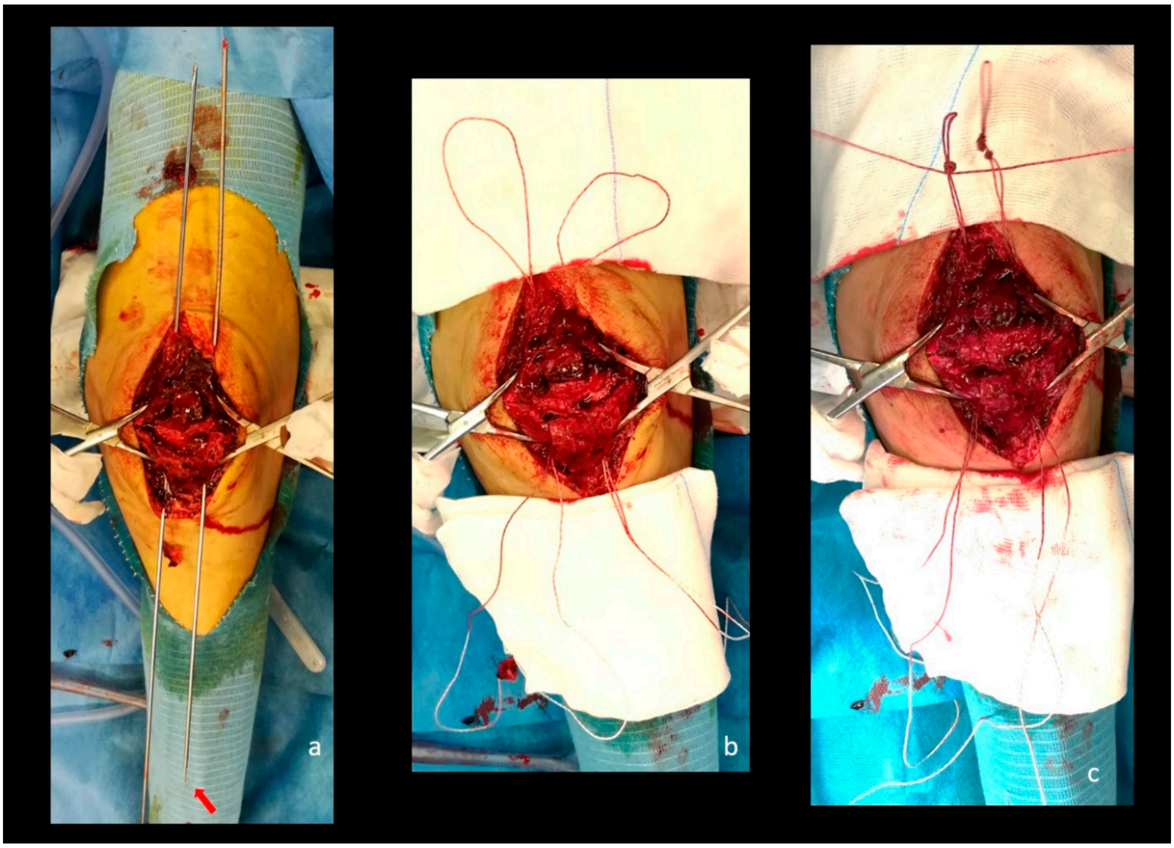

Figure 4. Clinical picture showing the phases described in the previous figure. (**a**) Two shuttle wires passing through the patella connected at the distal end with shuttle sutures attached to the looped FiberWire (red arrow); (**b**) No. 5 FiberWire sutures are passed through the patella with a loop on the upper pole; (**c**) a noose is created on the upper pole to prevent the lower migration of the FiberWire sutures. Note the third FiberWire passing through the inferior part of the nooses.

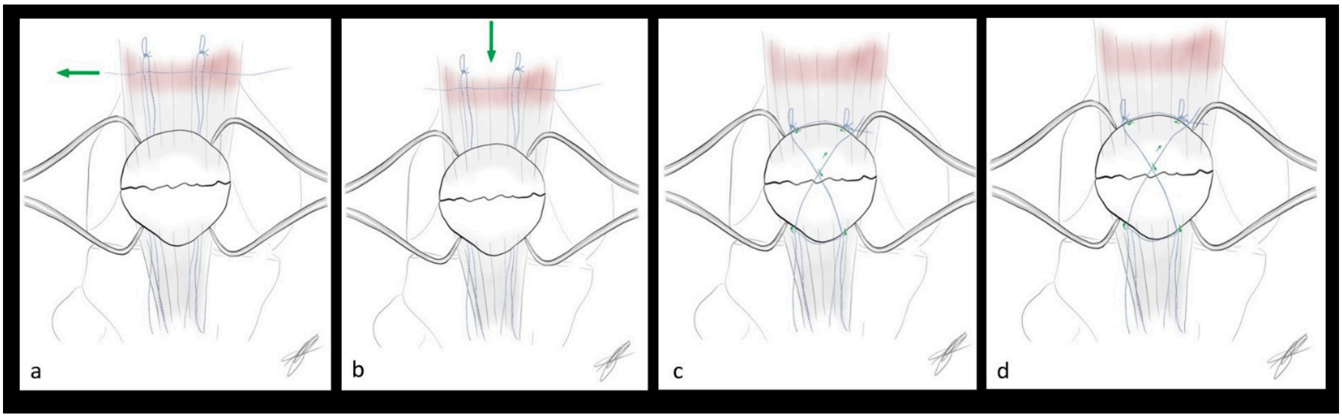

Figure 5. Drawing showing the final creation of the tension band. (**a**) A third FiberWire is passed below the nodes of the two parallel FiberWires (in the direction of the green arrow). (**b**) After passing the third Fiberwire over the superior pole of the patella, the parallel FiberWires are pulled down (see the green arrow). In (**c**,**d**) the third FiberWire was used to create the figure-of-eight suture.

2.2. Post-Operative Care

After surgery, an articulated knee brace is used in a fixed extended position for three weeks. Knee flection/extension exercises are then started, limiting the knee range of motion (ROM) from 0° to 90° for the next three weeks. Starting from the sixth week the ROM is no longer limited. Weight-bearing is allowed as tolerated from the third week after the surgery. Full weight bearing is permitted from the fourth week after the surgery if considered appropriate by the rehabilitation team. Patients were weekly followed up for 6 weeks after the surgery. At this point they were radiologically evaluated. Then, the patients were regularly followed up at 3, 6, 12, and 18 months after the surgery, both clinically and radiographically.

2.3. Patients

In order to better analyze the outcomes of the conceived surgery, a retrospective evaluation of non-consecutive patients was conducted by two independent evaluators. Ten non-consecutive patients (6M and 4F) with a mean age of 54.4 years (20–75) were treated using the proposed technique. The inclusion criteria were:

The presence of a transverse patella, lower pole or comminuted (with two major fragments on the articular surface, preferentially with a transverse fracture line) fractures;

- The time between the trauma and the surgery not exceeding 10 days;
- Patients with at least 18 months of follow-up.
- The exclusion criteria were:
- Non-union patellar fractures;
- The failure of previous treatment (i.e., metal cerclages);
- Previous total knee replacement of the same joint;
- Morphological alterations of the knee due to genetic anomalies or previous trauma.

As a standard procedure, knee function was evaluated using both the International Knee Documentation Committee (IKDC) and Lysholm scores. Thus, the endpoints of the study were set as follows: Number of patients requiring hardware removal; Lysholm score > 80 [15]; ICDK score > 77 [16].

As routinely performed, all patients signed a written consent form agreeing to undergo the procedure and allowing the use their data for audit and scientific purposes.

According to Italian law, formal ethical approval was not required because the present study includes routinely performed clinical and radiological evaluations. The present study has been performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

3. Results

The clinical results at a minimum of 18 months of follow-up (average 24.16; range 18.17–31.64) are showed in Table 1 and Figure 6. None of the patients required the removal of hardware during the follow-up. The Lysholm score mean was 91.90 with an STD of 7.59. The ICDK score mean was 85.10 with an STD of 5.82. Both scores were analyzed with a one-sample Wilcoxon test and proved statistically significant compared to value sets as endpoints. During the follow-up period, good pain control was reported by all patients. The union rate was 100%, no patient reported any discomfort at the patella either on palpation or on knee mobilization at final follow-up. No serious adverse events (i.e., infection) were reported by any of the included patients. All endpoints were reached. Figures 7 and 8 present a clinical case treated using our technique.

Table 1. Clinical outcomes of our cohort at final follow-up.

Patient	Gender	Age	Type of Fracture	Lysholm	IKDC
1	M	20	Transverse	100	92
2	M	53	Comminuted	88	78
3	F	66	Transverse	92	85
4	F	75	Transverse	86	80
5	M	45	Transverse	95	87
6	F	53	Transverse	100	93
7	M	55	Transverse	100	92
8	F	61	Comminuted	76	78
9	M	66	Inferior pole	89	81
10	M	50	Transverse	93	85

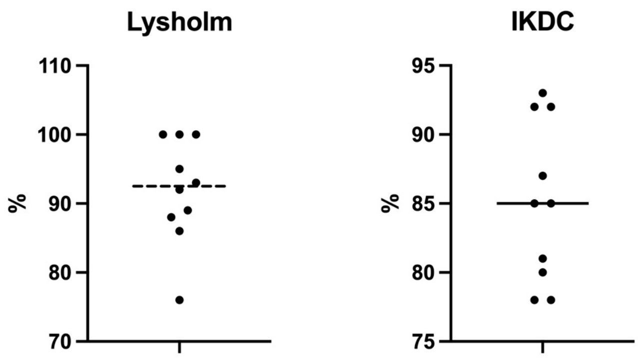

Figure 6. Lysholm and ICDK score (N = 10).

Figure 7. In (**a**,**b**) preoperative anteroposterior and latero-lateral views of a patellar fracture that occurred in a 66-year-old lady. In (**c**,**d**) post-operative radiographs.

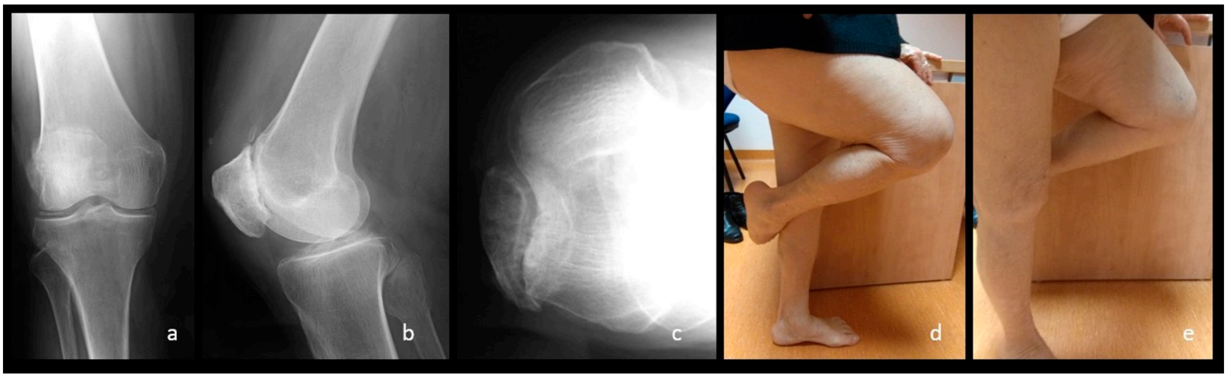

Figure 8. Radiographical (**a**–**c**) and clinical evaluations (**d**,**e**), performed at 8 months after the surgery. Please note the good knee function as compared with the non-affected side. A comparable-to--pre-operative radiographic stage two patella-femoral arthritis could be observed at final-follow up.

4. Discussion

The patella is generally affected by closed fractures related to direct trauma that generally leads to a two-part transverse fracture [2]. Indications for surgery for these types of fractures are based on the disruption of the extensor mechanism and a severe dislocation (>3 mm) [2,3].

Although, the comminuted fractures and those of the inferior pole of the patella have limited therapeutic options, including partial patellectomy and locking plates, a tension banding technique should also be used to preserve the extensor mechanism [2,3,12]. Although the introduction of anterior locking plates, either alone or in combination with metal cerclages, was associated with promising outcomes, their use is not risk free in terms of soft tissue complications (up to 13%) [17–19].

Most of the problems associated with the fixation stability of patellar fractures are related to their biomechanics. In fact, the patella increases the quadriceps lever arm and plays a key role in the resistance of knee flection, being subjected to relevant reaction forces, estimated to be 3–4 times of the bodyweight [2].

The tension band technique has been developed to resolve critical issues related to the biomechanics of the extensor mechanism. The tension band technique is generally based on the use of metal implants, including K-wires, cannulated screws and stainless steel wires [2,3,12]. Although viable, the use of these metal implants is not free of complications, most of them related to metal debris, metal wire migration, and soft tissue damage that leads to an impressive reoperation rate [3,5–7]. Some technical measures have been proposed to reduce the complication rate, including the use of absorbable screws and sutures [5,7].

FiberWire® is a reinforced braided polyblend suture that has been demonstrated to be superior to both stainless steel and other braided polyester sutures in terms of mechanical resistance [8,20]. In fact, Najibi et al. showed that No. 5 FiberWire presented a higher load to failure and stiffness compared to several types of sutures, including Ethibond Excel (Nos. 0 to 5), TiCron (Nos. 2 and 5), Vicryl (Nos. 2-0 to 1), and No. 2 FiberWire [20]. Given these results, the authors proposed the use of No. 5 FiberWire to treat patellar fractures [20].

Wright et al. compared No. 5 FiberWire suture with 18-gauge stainless steel wires, reporting a higher load to failure while maintaining its initial stiffness until failure. The authors concluded that FiberWire might be a superior alternative to stainless steel wires in fixing the tension band of the transverse patellar fractures [8].

These observations were later confirmed by Fortis et al. in a biomechanical study [13]. The authors reported a greater stiffness than metallic or other biodegradable sutures, and minimal soft tissue irritation [13]. This led some authors to start using FiberWire as well as other braided sutures to treat patellar fractures [4,5,7]. Camarda et al. conducted a retrospective investigation on the results of FiberWire cerclage in 17 displaced patella fractures, reporting favorable union and complication rates [5]. Two subsequent systematic reviews demonstrated that the use of non-absorbable sutures could be associated with both low complication and reoperation rates and equivalent clinical outcomes if compared to metallic wires [4,21]. However, most of the available studies used the non-absorbable sutures only as a substitute for the stainless steel wire to complete the figure-of-eight loop [4,5,11,14]. Obviously, this use did not remove the potential metal-related complications associated with K-wires or other metal implants. For this reason, Buezo et al. proposed a surgical technique based on a 2 mm nonabsorbable braided polyethylene suture passed through three transosseous tunnels and associated with a 3 mm absorbable suture to complete the figure-of-eight loop [22]. The authors reported no need for implant removal and no secondary displacements in the eight patients followed-up for at least 24 months [22]. A similar technique was used also by Swensen et al. for inferior pole patellar fractures, but using a No. 2 FiberWires and a No. 5 Ethibond [21].

However, theoretically, the need for numerous bone tunnels may increase the risk of malpositioning and reduce the bone stock, potentially increasing the risk of cortical fractures and suture loosening and failure [23–25]. This limitation could be overcome by reducing the number of bone tunnels. Bukva et al. proposed a surgical technique based on the use of a double parallel suture button in combination with a braided polyester tension-band, reporting good outcomes and no need of implant removal [26]. However, a potential drawback of this technique is the need for perfect bone tunnel positioning and soft tissue interposition underneath the suture buttons [26]. Our technique also overcomes the aforementioned potential drawbacks, reducing the number of bone tunnels needed to assure fracture compression and perpendicular stability, as well as the problems related to the interposition of soft tissues. Moreover, our technique has the potential advantage of positioning the bone tunnels in different inclinations to maximize bone compression and also treat more complex cases. In fact, Trinchese et al. used a similar technique along with platelet-rich-plasma to treat a case of non-union patellar fracture [27]. However, it is necessary to underline that the two comminuted fractures included in our cohort presented the worst outcomes, raising some questions on the effectiveness of our technique in these types of fractures. Our paper has some limitations. First of all, our cohort was evaluated only through clinical scores due to the lack of regular radiographic (including CT or MRI Scans) assessment that could lead to a better characterization of patient results (i.e., time to healing and degenerative changes in the patellofemoral joint). Second, the lack of a specific biomechanical study conducted on our technique, as well as the lack of specific data on secondary displacement during the follow-up period may raise some questions regarding fixation stability. However, by exploiting previous biomechanical observations of similar techniques and the adoption of a post-operative protocol based on controlled ROM and restricted weight bearing, as well as the good mid-term clinical outcomes, led us to be confident with the proposed technique. Finally, definitive data on time of surgery and tourniquet use are not available. However, reporting such data was beyond the main aims of our study.

5. Conclusions

The suture-only tension bend technique for patellar fractures is a promising technique to treat patellar fractures, with favorable outcomes and complication rates. The proposed technique makes it possible to stabilize the fracture through a tension band technique using a suture-only method, by using two bone tunnels and No. 5 FiberWire. This approach seems to be able to securely mobilize the knee joint at an early stage, while avoiding further surgeries for implant removal. However, both biomechanical and larger cohort studies including more in-depth radiographical evaluations are needed to confirm our data.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/std13020015/s1, Video S1 showing the tension band effect of the proposed technique in a comminuted fracture. Please note that, thanks to the stabilization of the two major fragments, only the outer part of the patella is slightly subjected to the tension forces. Figure S1 showing, in (a) and (b), the final realization of the tension banding using a third FiberWire to draw the figure of eight onto the non-articular surface of the patella, and tightening the lower parts of the two parallel FiberWires, which are then connected to the third FiberWire to fix the figure-of-eight loop. (c) Final appearance of the reduced and fixed fracture after retinacule suturing.

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