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Clinical Study on Percutaneous Intramedullary Bioresorbable Pin Fixation for Fourth and Fifth Metacarpal Bone Fracture

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Purpose: Metacarpal fracture of a ring and little finger occurs frequently. Percutaneous intramedullary fixation is a simple and effective method with a low incidence of complications. To date, Kirschner wire (K-wire) fixation has been widely used, but this has problems such as pin infection. Moreover it is difficult to start early active motion exercise. So, we replaced the K-wire with a bioresorbable implant and evaluated the results.

Methods: This study was conducted from 2014 to 2016 and involved 10 consecutive patients with 10 metacarpal neck fractures. All cases underwent percutaneous intramedullary fixation using the ActivaPin (Bioretec Ltd.) within 7 days after injury, and the average follow-up period was 13 months. At the final follow-up, all cases were assessed in terms of total active motion (TAM), bony union and angular deformity based on plain radiographs.

Results: The patients started active motion exercise within 1 week and regained a full range of motion after average 4 weeks. The TAM results were excellent at 250° to 270° in all cases. Regarding radiographic findings, fractures united in all cases and there were no malunion and knuckle deformity.

Conclusion: Replacement of a K-wire with a bioresorbable pin prevented soft tissue damage and dorsal scarring. And our percutaneous intramedullary bioresorbable pin fixation technique resulted in early recovery of range of motion and correction of deformity. The patients regained range of motion and returned to daily life early.

Keywords: Absorbable implants, Fracture fixation, Metacarpal bones

INTRODUCTION

A metacarpal neck fracture of a ring and little finger commonly occurs as result of direct trauma[1,2]. If these fractures are stable, they can be treated nonsurgically and severe functional problems are rare[3]. Surgical treatment is

justified for unstable, displaced fractures, open fractures, palmar dislocation over 30° and shortening over 5 mm, which affect extension and flexion of the hand[4]. These surgical techniques include percutaneous Kirschner wire (K-wire) fixation, external fixation, and plate and screw fixation[5-7]. K-wire is widely used for fixation in metacarpal bone fractures[8]. It is a simple and effective method with a low incidence of complications. But, in case of exposing outside the skin, it has some problems such as pin infection, damage to adjacent soft tissue, need for pin removal, and unattractive dorsal scarring. Moreover it is difficult to start early active motion exercise. To overcome these problems, we replaced the K-wire with a bioresorbable implant and evaluated the results.

MATERIALS AND METHODS

This prospective study was conducted from March 2014 to May 2016 and involved 10 consecutive patients with 10 metacarpal neck fractures that were treated operatively. The operative indication and acceptable angulation are debatable, but a dorsal apex angulation of greater than 30° at the ring and little fingers and shortening of more than 5 mm were corrected by operation. All cases underwent surgery within 7 days after injury, and the average follow-up period was 13 months (range, 12–15 months). Comminuted fractures and irreducible metacarpal spiral shaft fractures by closed manipulation were excluded. At the final follow-up, all cases were assessed in terms of total active motion (TAM), bony union and angular deformity based on plain radiographs.

1. ActivaPin device

The ActivaPin (2.0 mm×70.0 mm; Bioretec Ltd., Tampere, Finland) are constructed of bioresorbable lactic/glycolic acid copolymer (PLGA). These polymers degrade *in vivo* by hydrolysis into alpha hydroxy acids that are metabolized by the body. ActivaPin maintains its function at least 8 weeks. Bioresorption takes place within approximately 2 years thus eliminating the need for implant removal surgery. ActivaPin has grooved surface design, and it contributed to a self-locking effect with the adjacent the bone (Fig. 1).

2. Surgical technique

The procedure was performed under general anesthesia or brachial plexus anesthesia. We reduced the fracture using the Jahss maneuver, in which distal interphalangeal joints and proximal interphalangeal (PIP) joints were flexed and dorsal pressure was applied to the PIP joint while counter pressure was applied to the dorsal apex of the fracture site[9]. After selecting the appropriate diameter ActivaPin, a hole that corresponds to the pin diameter was drilled through the fracture plane using the ActivaPin guided K-wire (Figs. 2, 3). To produce an accurate hole at the site of the ActivaPin, the ActivaPin guided K-wire was applied under C-arm guidance. The ActivaPin is designed 2 mm shorter than inserted guided pin length so that it sinks the pin 1–2 mm to prevent the head of the pin protruding, which can cause soft tissue irritation. Then, the pin was picked by pushing the ActivaPin applicator piston. The attached pin and the piston were slid inside the ActivaPin sleeve and the pin was introduced into the hole by sliding the piston. During pin insertion, the sleeve and pin were held parallel to the long axis of the drill hole to slides easily to the drill hole. Finally, skin was repaired using 5-0 Nylon.

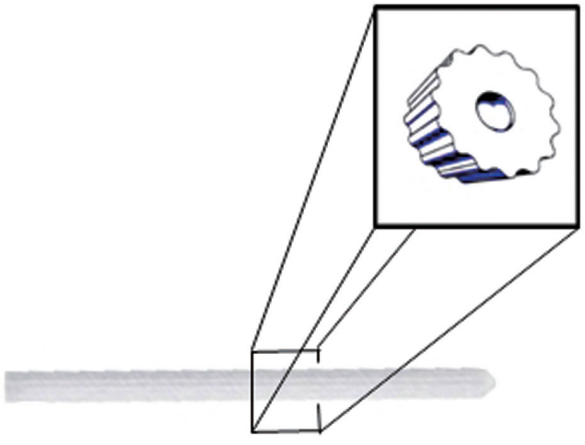

Fig. 1. ActivaPin (2.0 mm×70.0 mm; Bioretec Ltd.) has grooved surface design, and it contributed to a self-locking effect with the adjacent the bone.

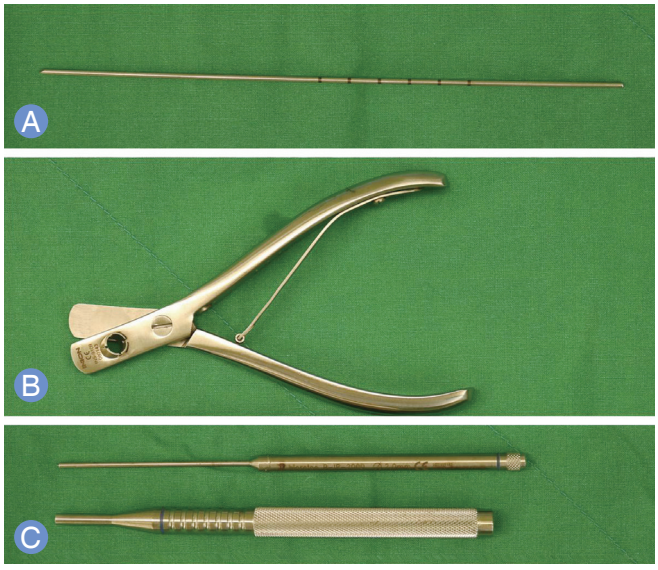

Fig. 2. The ActivaPin (Bioretec Ltd.) device. **(A)** ActivaPin guide Kirschner wire was used to produce an accurate hole at the site of the ActivaPin. **(B)** ActivaPin cutter cut the ActivaPin 2 mm shorter than inserted guided pin length. **(C)** ActivaPin piston (upper) attached ActivaPin and slide inside the ActivaPin sleeve (lower).

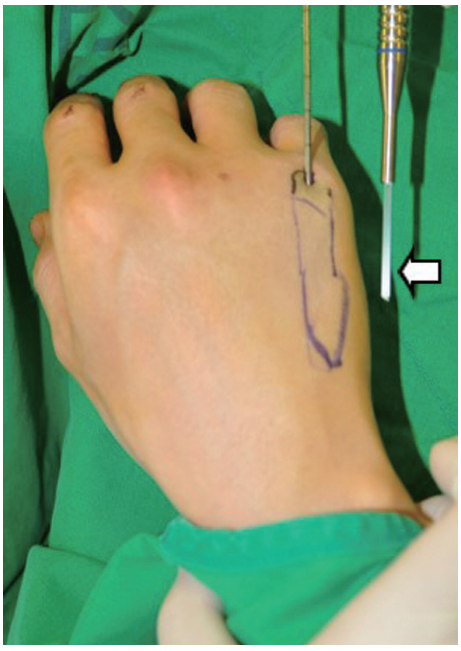

Fig. 3. Intraoperative photograph. To produce an accurate hole where the ActivaPin (arrow; Bioretec Ltd.) is located, a Kirschner wire is inserted percutaneously into the intramedullary canal with flexion of the metacarpophalangeal joint.

3. Postoperative care

After surgery, a dorsal short arm splint was applied in the intrinsic-plus position, which maintained the wrist extended at about 30°, the metacarpophalangeal joint flexed at about 80°–90°, and the interphalangeal joints fully extended. Within 1 week, patients started active motion exercise with the splint in place. At 3 weeks after surgery, splinting was removed.

RESULTS

Seven cases were males and 3 were females. Their average age was 33.8 years (range, 18–45 years). Seven cases were fourth metacarpal neck fractures, and 3 were fifth metacarpal neck fractures. Regarding the causes of injury, 5 cases were direct blows, 3 cases were slip downs, and 2 cases were sports injuries (Table 1). Regarding radiographic findings, fractures united in all cases in about

Table 1. Patient's demographics and results

No.	Sex/age (yr)	Fracture site	Injury mechanism	Radiologic union period (wk)	Clinical result* (°)
1	Male/18	Fourth metacarpal neck	Sport injury	5	270
2	Male/25	Fourth metacarpal neck	Direct blow	5	260
3	Male/27	Fourth metacarpal neck	Sport injury	5	260
4	Male/35	Fourth metacarpal neck	Direct blow	6	260
5	Male/41	Fourth metacarpal neck	Direct blow	6	250
6	Male/32	Fifth metacarpal neck	Direct blow	5	260
7	Male/45	Fourth metacarpal neck	Slip down	6	270
8	Female/42	Fourth metacarpal neck	Direct blow	5	260
9	Female/35	Fourth metacarpal neck	Slip down	6	260
10	Female/38	Fifth metacarpal neck	Slip down	7	250

*Total active motion.

6 weeks (range, 5–7 weeks) after the operation (Fig. 4). Angulation of less than 5° was observed in 1 case. No case showed rotational deformity and shortening. The patients started active motion exercise within 1 week, and the patient regained full range of motion after average 4 weeks. The TAM results were excellent at 250° to 270° in all cases. There were no postoperative complications.

DISCUSSION

Fifth metacarpal neck fracture, commonly referred to as boxer's fracture, is the most common injury, accounting for 20% of total hand fractures[10]. It is relatively easy due to the fifth metacarpal bone is thinner than others and the weak protection of surrounding tissues. The treatment of unstable metacarpal fractures is very diverse and is performed in a variety of ways depending on the location of the fracture, fracture type, presence of coexisting injuries, soft tissue condition, and experience or preference of the surgeon[11].

Many articles have reported that conservative treatment alone has resulted in excellent results in the treatment of fifth metacarpal neck fractures. However, it can occur depressed knuckle on dorsum of hand due to residual angular deformity after conservative treatment. Then, conservative treatment alone is difficult to obtain satisfactory treatment[12]. Surgical treatment can effectively correct the angulation and maintain the fixation of the fracture. In addition, unlike conservative treatment, it has the advantage of minimizing the fixation period and enabling early joint motion.

Internal fixation using a metal plate has been widely used because it has the strongest fixation force and enables early exercise[13-15]. However, there is an increased risk of soft tissue damage, resulting in extension problems, stiffness, tendon rupture due to metal plates and

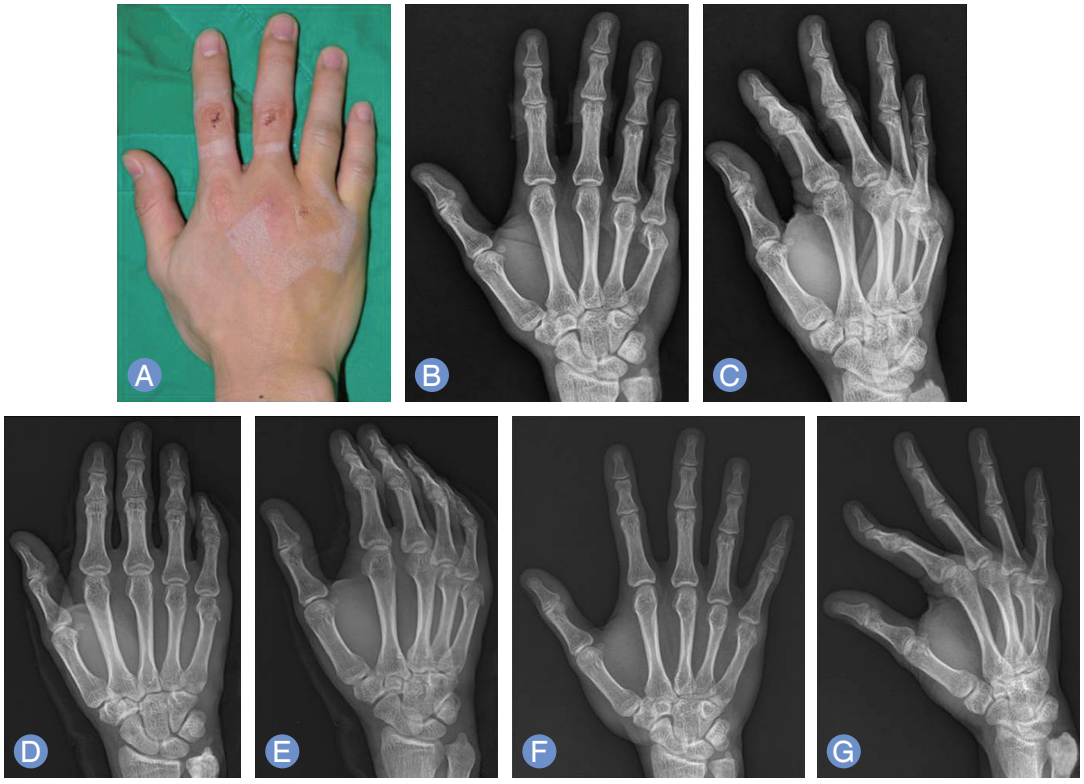

Fig. 4. Preoperative clinical photograph and simple radiograph. **(A–C)** Preoperative photographic and X-ray findings of a 32-year-old male with a fifth metacarpal neck fracture. **(D, E)** X-ray at 1 day postoperatively showing a percutaneous intramedullary bioresorbable pin fixation state. **(F, G)** At 6 months after the operation, radiographs show bony union without dorsal angulation.

screws. And the removal of the metal plate is required. K-wire is widely used for fixation in metacarpal bone fractures[8]. Pin fixation was first described as a retrospective method for treatment of metacarpal fracture by Lord[16] in 1957. Later various surgical techniques were devised, which transformed this method, and good clinical outcomes were reported[5,8,17]. Choi and Chang[18] reported good clinical outcomes without damage and adhesion of the proximal extensor tendon, no disturbance of metacarpophalangeal joint movement, using retrograde intramedullary pin fixation of the fourth and fifth metacarpals. However, accordingly skin irritation due to the pin and local infection can occur, and in particular, movement of the pin and perforation of the condyle are major complications[8]. In case of exposing outside the skin, it has some problems such as pin infection, damage to adjacent soft tissue, need for pin removal, and unattractive dorsal scarring. Moreover it is difficult to start early active motion exercise.

Therefore, we replaced the K-wire with ActivaPin, a bioresorbable implant constructed of bioresorbable PLGA, which is degraded in vivo by hydrolysis into alpha hydroxy acids and metabolized by the body. ActivaPin does not protrude from the skin, and so does make less the problems such as pin infection, damage to adjacent soft tissue, need for pin removal, and unattractive dorsal scarring. Its bioresorbability eliminates the risk of long-term complications and removal surgery. ActivaPin may be considered weak for the force of rotational deformity since only one was used. But, the locking of the pin occurred with adjacent the bone because of having been designed the grooved surface. It is of high strength and enables stable fixation, easy insertion and safe medical use.

The period of active motion after K-wire fixation in the medullary canal differs among studies. Various periods have been reported, including active motion immediately and 4 weeks after surgery[5,6,8,19]. However, during early movement of the joint, K-wire fixation may cause irritation due to the pin, movement of the pin and reduction loss. If joint movement is delayed, contracture occurs in the joint region, and a normal range of motion is unlikely to be achieved. In contrast, ActivaPin does not protrude from the skin, early active motion was possible. Patient started gentle active motion exercise within 1 week, and splinting was completely removed after 3 weeks. They all regained full range of motion after postoperative 4–5 weeks.

It is difficult to use fixation with ActivaPin for shaft fractures for which closed reduction is impossible, comminuted fracture and condylar and base fractures, and in patients with an extremely narrow medullary canal of the metacarpal shaft. Because ActivaPin pass through the articular surface of the metacarpal head when it is inserted, they may also damage the metacarpal joint. Lastly, in our study, we applied this method only to the fourth and fifth metacarpal fracture because we had only a small case of other metacarpal fracture. And it has a limitation that the observation period is only 1 year. More studies will be needed in the future with more surgery and a longer follow-up period.

CONCLUSION

K-wire exposed to the outside of the skin has some problems such as pin infection, damage to adjacent soft tissue, and unattractive dorsal scarring. And it is difficult to start early active motion exercise. Moreover it needs to be removed. Replacement of a K-wire with a bioresorbable pin prevented soft tissue damage, dorsal scarring and no need to remove. It does not also protrude from the skin, early active motion was easily possible. And our percutaneous intramedullary bioresorbable pin fixation technique resulted in early recovery of range of motion and prevention of stiffness. It helps patients regain close to normal range of motion and returned to daily life early.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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제4 및 제5중수골 골절의 흡수성 핀을 이용한 경피 골수강 내 고정에 대한 예비 연구

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목적: 중수골 골절은 흔하게 생길 수 있는데, 지금까지는 주로 K-강선을 이용한 고정 방법이 사용되어 왔으나 이 방법은 감염과 같은 합병증이 발생할 수 있으며, 수술 후 초기에 관절운동을 하기 힘들다는 단점이 있다. 그래서 저자들은 이 같은 단점을 극복하고자 흡수성 내고정물을 사용한 후 그 결과를 확인해 보았다.
방법: 2014년부터 2016년까지 본원에 내원한 환자 10명의 중수골 골절을 대상으로 하였다. 모든 환자들에게 손상 후 일주일 이내에 흡수성 내고정물인 ActivaPin (Bioretec Ltd.)을 이용하여 경피 골수강내 고정을 시행하였다. 수술 후 환자들은 총 능동운동을 측정하였고 영상의학 검사를 통해 골유합과 각 변형의 정도를 확인하였다.
결과: 총 능동운동은 모든 환자에서 250°-270°로 우수한 결과를 나타냈다. 영상의학 검사를 통하여 확인한 결과 모든 환자에서 골절의 유합이 이루어졌고 특별한 합병증은 관찰되지 않았다.
결론: K-강선을 흡수선 핀으로 교체하여 사용함으로써 주변 조직의 손상이나 손등 부위의 흉터를 예방할 수 있었다. 또한 흡수성 핀을 이용한 경피 골수강내 고정 방식은 수술 후 초기에 운동을 가능하게 한다. 따라서 관절이 굳거나 하여 발생하는 변형을 예방할 수 있었고 완전한 관절 운동범위로 회복이 가능하였다.

색인단어: 골절 고정, 중수골, 흡수성 보형물

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