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Lasso loop technique using bioabsorbable thread to treat intra-articular distal radius fracture

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Abstract

This article introduces our lasso loop technique (LLT) using a bioabsorbable thread for the treatment of intra-articular distal radius fractures with displaced dorsal bone fragment containing articular surface (DBF). We also examined whether the articular gap is sufficiently reduced and maintained by the LLT, along with the results of other radiological and clinical evaluations. We retrospectively reviewed 19 patients who underwent LLT for intra-articular distal radius fracture with a displaced DBF. Patient radiographic images and medical records were used to investigate radiological characteristics, symptoms, physical findings, and the Quick Disabilities of the Arm, Shoulder, and Hand scores. Sagittal-view computed tomography showed that the mean preoperative articular gap was 2.6 mm, but the gap was reduced by LLT, and the gap immediately postoperatively was <1.0 mm in all patients. No re-displacement of the DBF was evident from immediately postoperatively to 6 months postoperatively. Postoperatively, no losses of correction in palmar tilt, radial inclination, or ulnar variance were seen in the evaluation of plain radiographs, and satisfactory joint range of motion, grip strength, and the Quick Disabilities of the Arm, Shoulder, and Hand score were obtained. No significant complications due to LLT were observed. LLT appears to offer a simple and effective procedure to reduce displaced DBF with little risk of complications. LLT may become a useful option in the treatment of intra-articular distal radius fractures with displaced DBF.

Abbreviations: CT = computed tomography, DBF = dorsal bone fragment containing articular surface, LLT = lasso loop technique, PT = palmar tilt, qDASH = the Quick Disabilities of the Arm, Shoulder, and Hand, RI = radial inclination, UV = ulnar variance, VBF = volar bone fragment containing articular surface.

Keywords: articular gap, articular step-off, distal radius intraarticular fracture, dorsal bone fragment, lasso loop technique

1. Introduction

Various treatments have been performed for distal radius fractures, but most treatments for such fractures in recent years have been performed using a volar locking plate.[1] Osteosynthesis using the volar locking plate offers excellent support of the joint surface with locking screws, and clinical results for distal radius fractures have improved dramatically since the introduction of this technique. However, since the bone fragments are fixed only by screw from the volar side, one weakness is that the dorsal bone fragment containing articular surface (DBF) cannot be sufficiently fixed in intra-articular fractures.[2,3]

After osteosynthesis using a volar locking plate for intra-articular fractures with DBF, we often encounter cases in which articular gaps and step-offs recur after surgery, even though a reduction in the articular surface has been confirmed arthroscopically (Fig. 1). Dorsal plate fixation[2,4] and integrated compression screw[5,6] have been reported as means for solving such problems. However, dorsal plate fixation may irritate the extensor tendons,[7–9] and dorsal monocortical screws may not exert sufficient fixation force in osteoporotic cases. Fixation with an integrated compression screw offers an excellent technique to alleviate the problem of irritation of the extensor tendons.[5,6] Further, since the screw from the dorsal side is connected to the screw from the volar side, fixation force is also higher.[3] However, concerns about irritation of the extensor tendon have not been completely eliminated,[6] and one weakness is that the position of dorsal screw insertion is defined by the volar-side screw position.

To address these problems, since 2018, we have been trying to reduce the articular gap and increase fixation force to the DBF by fastening the DBF and volar bone fragment containing articular surface (VBF) using a bioabsorbable thread, such as in the lasso loop technique (LLT).

This article introduces our LLT for intra-articular distal radius fractures with DBF. We also examined whether the gap distance is satisfactorily reduced by the LLT and whether the reduced gap distance can be maintained after surgery. In addition, the clinical results of patients who underwent LLT were also evaluated.

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The authors have no conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Figure 1. A representative case of intra-articular distal radius fracture treated with the standard volar locking plating technique. Preoperative (A) and postoperative (B) sagittal-view CT. Postoperative sagittal-view CT shows a residual articular gap. CT=computed tomography.

2. Materials and methods

This study was conducted with the approval of the ethics committee at our institution, and informed consent for publication of this article was obtained from the patients. A retrospective chart review was performed on patients who underwent arthroscopic reduction, volar locking plate fixation, and LLT for intra-articular distal radius fracture with DBF between October 2018 and December 2020. Other inclusion criteria were preoperative sagittal-view computed tomography (CT) showing an articular gap distance ≥1.5 mm between the DBF and VBF. Exclusion criteria were complications of other peripheral fractures such as distal ulnar fractures, combined external fixation, and lack of assessment of physical findings and X-ray imaging studies at appropriate postoperative time points.

2.1. Surgical technique

All LLT was performed by the same experienced hand surgeon (YK).

First, the fracture site was exposed using a trans-flexor carpi radialis approach, then the displaced bone fragments were roughly reduced under direct vision and fluoroscopy. The articular step-off was then reduced under arthroscopy, and the DBF and VBF were temporarily fixed with a 1.0-mm-diameter Kirchner wire inserted from the volar side to maintain the reduced position. Usually, some amount of articular gap remained at this point. Subsequently, the fracture was fixed with a volar locking plate using standard techniques, and the Kirchner wire used for temporary fixation was removed. The plates used were HYBRIX or HYBRIX-D (MIZUHO Medical Innovation, Tokyo, Japan). After osteosynthesis, 2 1.0-mm-diameter Kirchner wires were inserted from the wire hole of the plate or outside the plate toward the DBF to create 2 bone holes, then advanced to the dorsal subcutaneous region. Using these wires as landmarks, a small incision was made on the dorsal skin of the wrist joint. After making a partial incision in the extensor retinaculum, the extensor tendons were shifted to the radial or ulnar sides of these 2 wires. If the posterior interosseous nerve was present between the 2 Kirchner wires, it was excised at this time. The Kirchner wires were then removed, and 2 cannulated passers which were made to fit the wire holes of HYBRIX or HYBRIX-D were passed through the same holes from the volar side, and 2-0 absorbent braided thread (CROSS SORB; BEAR Medic Corporation, Ibaraki, Japan) with straight needles at both ends was inserted into the passers from the dorsal side, and the thread was sent to the volar side by pulling out the passer. The DBF was then compressed toward the VBF using plate-grasping forceps to reduce the gap distance. After confirming arthroscopically that the gap distance had been reduced, the DBF was fixed by fastening the absorbent thread, while applying pressure to the DBF with the forceps (Fig. 2).

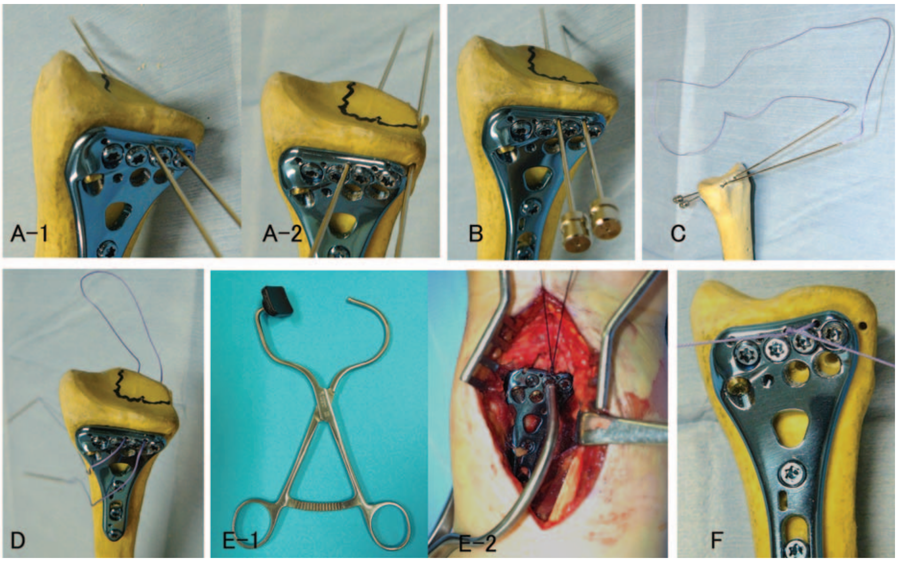

Figure 2. The lasso loop technique. Two Kirchner wires are inserted from the wire hole of the plate (A-1) or outside the plate (A-2) toward the dorsal bone fragment. Two cannulated passers are passed through the same holes from the volar side (B). Absorbent thread with straight needles at both ends is inserted into the passers from the dorsal side (C), and is sent to the volar side (D). The dorsal bone fragment is compressed toward the volar bone fragment using plate-grasping forceps (E-1, 2). The dorsal bone fragment is fixed by fastening the absorbent thread (F).

Postoperatively, active and active assistive range of motion exercises of the wrist joint were started the day after surgery and the exercise level was gradually increased. The wrist joint was protected with a removable plastic splint for 1 to 2 weeks, with the splint removed during rehabilitation.

2.2. Radiological evaluation

For radiological evaluations, articular gap distance was measured using sagittal-view CT taken before and immediately after surgery (≤7 days after surgery) to evaluate the effects of LLT on reducing the gap distance. We also measured the articular width before surgery, immediately after surgery, and 6 months after surgery to evaluate whether the reduced gap distance had again increased. Articular width was assessed because osteogenesis at the fracture site prevents accurate gap distance assessment using CT at 6 months. We therefore measured articular width instead of gap distance, because articular width reduces as gap distance reduces. We also measured the articular step-off before surgery, immediately after surgery, and 6 months after surgery (Fig. 3). All measurements from CT images were performed using the position at which gap distance was maximal on preoperative sagittal-view CT images according to the methods described by Cole et al.[10] In addition, palmar tilt (PT), radial inclination (RI), and ulnar variance (UV) were measured immediately after surgery and 6 months after surgery using posteroanterior- and lateral-view plain radiographs. All radiological measurements were performed using the computer-aided measurement software included in the PACS system (SYNAPSE; FUJIFILM Medical Co., Tokyo, Japan). Values from preoperatively to immediately postoperatively and from immediately postoperatively to 6 months postoperatively were compared using the Wilcoxon signed-rank test. The level of significance was set at $P < .05$. All radiological measurements were performed by the same experienced hand surgeon (KY).

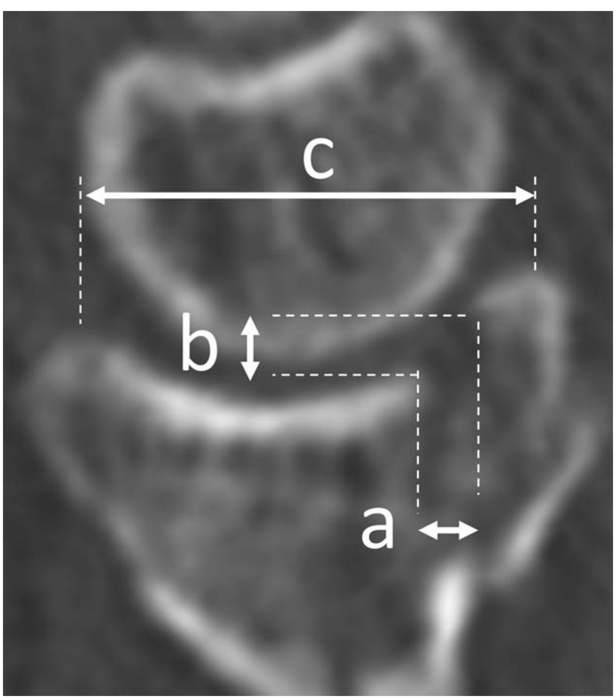

Figure 3. Sagittal-view CT taken for the measurement of articular gap distance (A) and step-off (B). Since evaluating articular gap accurately at 6 months after surgery is difficult due to the effect of osteogenesis, we evaluated changes in articular width (C) instead of measuring gap distance. Gap distance was measured preoperatively and immediately postoperatively. Step-off and articular width were measured preoperatively, immediately postoperatively, and at 6 months postoperatively. CT = computed tomography.

2.3. Symptoms and physical evaluation

Data on patient symptoms and physical findings (wrist pain, grip strength, range of motion of the wrist), and the Quick Disabilities of the Arm, Shoulder, and Hand (qDASH) scores at 6 months after surgery were extracted from electronic medical records. The reason for evaluation at 6 months postoperatively is that many patients undergo plate removal 6 months after surgery in Japan, so the above evaluations were made 6 months after surgery, which is unaffected by the plate removal surgery. Grip strength was evaluated using a Smedley-type hand dynamometer (GRIP-D; Takei Scientific Instrument Co., Niigata, Japan). Ranges of motion of the wrist joint were evaluated for dorsiflexion, palmar flexion, pronation, and supination angles using a standard goniometer (Todai-shiki goniometer; Matsuyoshi & Co., Tokyo, Japan).

3. Results

Nineteen of the 30 patients who had sustained intra-articular fractures of the distal radius with DBF and presented to our institution met all the eligibility criteria and participated in this study. These participants comprised 4 men and 15 women, with a mean age of 66.0 years. Basic demographic information, fracture types, and causes of injury are summarized in Table 1.

3.1. Radiological results

At the 6-month postoperative follow-up, bone union was observed in all cases. Mean preoperative gap distance on CT was 2.6 mm, whereas postoperative gap distance was reduced to <1.0 mm in all cases. Articular width was significantly reduced from preoperatively to immediately postoperatively with the reduction of the gap. No significant difference was evident between articular widths immediately and at 6 months postoperatively, suggesting that the reduced articular width was maintained until 6 months postoperatively. A small amount of step-off was seen immediately after surgery in some cases, but no increase in step-off was evident by 6 months after surgery (Table 2). In the measurement of PT, RI, and UV from plain radiographs, UV tended to be slightly increased after surgery, but no significant changes were evident in any parameters from immediately to 6 months postoperatively (Table 3). A represen-

Table 1

Demographic data of participating patients.

Mean age (years)	66.0 (range 21–82)
Sex (M/F)	4/15
AO/OTA type (C1/C2/C3)	5/9/5
Mechanism of injury, n (%)	
Fall from standing	15
Snowboarding	2
Motor vehicle accident	1
Fall from height	1

Table 2

Radiographic measurement (computed tomography images).

	Before surgery	Immediately after surgery	Six months after surgery
Articular gap (mm), mean ± SD	2.6 ± 1.3	0.5 ± 0.2*	Not measured
Articular width, mm, mean ± SD	18.6 ± 1.9	16.6 ± 1.4*	16.8 ± 1.4
Articular step-off, mm, mean ± SD	0.7 ± 0.7	0.3 ± 0.4*	0.5 ± 0.9

* $P < .01$ compared with the value before surgery.

tative case is shown at the time of injury, immediately after surgery, and at 6 months after surgery in Fig. 4.

3.2. Symptoms and physical findings

Mild wrist pain was observed in 3 patients. However, the pain was localized to the palmar side, and no cases showed dorsal wrist pain due to suture-induced irritation. The mean ratio of grip strength on the affected side to that on the healthy side was 82.1%. Mean ranges of motion of the joints were 69.5° for dorsiflexion, 65.3° for palmarflexion, 79.2° for pronation, and 88.7° for supination. Mean qDASH score was 13.5 (Table 4).

4. Discussion

The standard surgical treatment for distal radius fractures is currently volar locking plate fixation.[1] However, in surgery for intra-articular distal radius fractures with DBF, locking screws from the volar side sometimes do not work sufficiently well to allow fixation of the DBF.[2,3] Bicortical screw fixation can be expected to provide stronger fixation, but such fixation is not usually performed because of the risk of extensor tendon damage.[11,12]

We have performed arthroscopic reduction and volar locking plate fixation for intra-articular fractures. When fixing the displaced DBF, the DBF was pressed against the VBF using plate-grasping forceps, and the locking screw from the volar side was inserted toward the DBF after confirming reduction of the articular gap and step-off under arthroscopic view. However, we often encountered cases in which the gap recurred as soon as the forceps were removed, or cases in which recurrence of the gap and step-off was confirmed on CT taken several days after surgery.

Regarding the importance of fixing the DBF, Hart et al[13] reported that when stress is applied to the articular surface after fixation of the volar plate, displacement occurs from the fragment of the dorsal lunate fossa. In addition, since the DBF forms part of the distal radioulnar joint as well as the radiolunate joint, proper repair is important. We therefore consider that firm fixation of the DBF using some additional techniques is very important. To date, some attempts at using dorsal plates or an integrated compression screw have been made for fixing DBF.[2–6]

Figure 4. A representative case treated with LLT. Plain radiographs and sagittal-view CT preoperatively (A), immediately postoperatively (B), and 6 months postoperatively (C). Preoperative articular gap and step-off are reduced, and the reduced position is maintained until 6 months after surgery. CT = computed tomography, LLT = lasso loop technique.

Table 3

Radiographic measurement (plain radiographs).

	Immediately after surgery	Six months after surgery
Palmar tilt, °, mean ± SD	13.1 ± 4.3	13.1 ± 4.4
Radial inclination, °, mean ± SD	23.5 ± 3.6	22.8 ± 3.2
Ulnar variance, mm, mean ± SD	1.1 ± 1.3	1.4 ± 1.2

Table 4

Symptoms, physical findings, and qDASH.

Wrist pain (none / mild / moderate / severe)	16 / 3 / 0 / 0
Ratio of grip strength to healthy side (%), mean ± SD	82.1 ± 19.4
Range of motion, °, mean ± SD	
Dorsiflexion	69.5 ± 8.0
Palmarflexion	65.3 ± 7.9
Pronation	79.2 ± 5.1
Supination	88.7 ± 4.2
qDASH (point), mean ± SD	13.5 ± 17.2

qDASH = Quick Disabilities of the Arm, Shoulder, and Hand.

Dorsal plate fixation using the dorsal approach provides the surgeon with the benefit of reducing the DBF under direct vision. However, concerns have been raised regarding hardware-related irritation of the extensor tendons and weak fixation force of the dorsal screw.[7–9] Fixing DBFs with an integrated compression screw such as the Frag-Loc Compression screw is one of the best procedures for fixing the DBF. This provides maintenance of postoperative reduction and does not appear to cause serious complications, at least in the short term.[5,6] However, although the integrated compression screw shows a low profile, it cannot be said to completely prevent irritation of the extensor tendons, and integrated compression screw fixation has been reported to cause extensor tendon synovitis.[6] Another problem is that the position of the compression screw from the dorsal side is determined by the position of the volar-side screw. If the plate is not placed in the proper position, the compression screw from the dorsal side cannot be inserted in the proper portion.

To overcome such problems, we devised the LLT introduced here. This method is superior to the integrated compression screw in terms of low profile, and since an absorbent thread is used in this procedure, the risk of irritating the extensor tendon will be more reduced after the thread is absorbed. In addition, since the position in which the thread is hung can be changed according to the shape and size of the bone fragment, more secure fixation is considered to be achievable. Moreover, the LLT is very simple and easy for surgeons who have mastered basic surgical techniques.

On the other hand, concerns regarding LLT include whether the suture thread can reduce the bone fragments by itself and whether the fixation force is sufficient to maintain the reduced position of the bone fragments. Regarding the reduction of the DBF, reducing the bone fragment by suture threads alone may be difficult, and if reduction is forcibly attempted, the fragile DBF may be damaged. To address this problem, we reduce the DBF using plate-grasping forceps which has a relatively large area of the grasping surface, and fasten the suture thread while pressing the DBF with the forceps. In addition, we use a relatively thick absorbent thread because the strength of the thread is an issue when it comes to maintaining the reduced position of the DBF. In-house data on the 3-0 size of CROSS SORB is open to the public. According to those data, the 3-0 CROSS SORB used in our LLT has an initial tensile strength of 27 N, and tensile strength remains at 65% at 2 weeks and 35% at 3 weeks. Since the 2-0 CROSS SORB offers stronger tensile strength than the 3-0, the suture thread is considered to maintain sufficient strength at least until fibrous union or callus formation begins at the fracture site.

Lee et al[5] reported that when using the integrated compression screw, the mean preoperative gap distance was 2.3 mm and the mean postoperative gap distance was 0.7 mm. Based on those results, the improvement rate in gap distance was 69.9%. In the present report using LLT, the mean preoperative gap distance was 2.7 mm and the mean postoperative gap distance was 0.6 mm, for an improvement rate of 77.7%, equal to or higher than that reported by Lee et al.[5] Furthermore, in this study, the ability to maintain a reduced gap distance was evaluated by measuring changes in articular width, with no significant increase in articular width observed after surgery. Therefore, this procedure may be considered to exert a sufficient effect in reducing the gap distance and maintaining thus reduction.

Opinions vary regarding the need to reduce the articular gap and step-off. Since Knirk and Jupiter[14] reported that accurate joint surface recovery represents the most important factor for successful long-term outcomes, joint reduction has been one of the most important issues in treating distal radius fractures. Some reports have indicated that displacements exceeding 1 to 2 mm are associated with poor performance and posttraumatic arthropathy.[15,16] Lee et al[5] recommended reducing displacement of the dorsal ulnar fragment >2 mm to prevent arthritic changes. On the other hand, several reports have stated that remnant displacements do not affect stability or clinical results,[17,18] especially when DBFs are 2 to 3 mm thin.[19] Whether the articular gap and step-off affect the onset of arthropathy and clinical outcomes thus remains controversial. However, most of those reports have involved follow-up of about 1 year, and complications such as arthropathy cannot be guaranteed to not occur over a long period of time. We therefore believe that the gap should be reduced as much as possible, and we are trying to reduce the gap or step-off to within 1 mm. However, under the current circumstances in which the importance of the residual gap remains controversial, performing treatment with excessive invasiveness or risks of extensor tendon disorder is not desirable.

The procedure we have introduced here appears less invasive than dorsal plate fixation, which requires a large surgical field. Furthermore, since an absorbent thread is used, the risk of extensor tendon disorder seems very low. In fact, we did not find any dorsal wrist pain or extensor tenosynovitis due to extensor tendon irritation in patients treated using this procedure. In addition, grip strength, ranges of motion of the wrist, qDASH, and correction of distal radial alignments such as PT, UV, and RI were comparable to those in previous reports.[20–23] We therefore considered that LLT represents a good treatment option in the treatment of intra-articular distal radius fractures with DBF.

Some limitations to this study merit consideration. One was the retrospective case series design. Larger-scale randomized controlled trials are needed to discuss the efficacy of LLT more robustly.

A second limitation was the relatively short follow-up period. However, this study examined whether LLT could reduce the gap distance and maintain this reduced position. Bone union after distal radius fracture is well known to usually be achieved within 6 months after surgery. In all cases in the present study, bone union was obtained before then. Since re-displacement will not occur after bone union, we thought that 6 months of follow-up was probably sufficient if we were only examining the reduction effect of LLT.

In conclusion, LLT using absorbent thread was considered to provide a simpler, less-invasive procedure that is applicable to various volar locking plates with wire holes. In addition, the ability of the LLT to reduce gap distance was comparable to that with integrated compression screws, and the reduced gap distance was adequately maintained until bone union. Furthermore, no significant complications were observed. These facts suggest that LLT may represent a useful treatment option for intra-articular distal radius fractures with DBF.

Author contributions

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Investigation: Yoshio Kaji, Kunihiko Oka.
Methodology: Masashi Shimamura, Shohei Kawakami.
Supervision: Tetsuji Yamamoto.

Writing – original draft: Yoshio Kaji.
Writing – review & editing: Konosuke Yamaguchi, Tetsuji Yamamoto.

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