

Change in Reduced Position after Locking Plate Surgery for Intra-Articular Fracture of the Distal Radius

—Evaluation by Tomosynthesis—

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1. Background

Because the angle-retaining characteristics of locking plates provide good retention of fractures in a reduced position, they are said to be especially effective in treating intra-articular fractures. However, previous reports only involved measurements using radiography (Xp) and there are no reports of evaluating whether joint surfaces were retained in a reduced position after surgery^{1), 2), 3), 4)}. CT is excellent for evaluating inside joints⁵⁾, but an alternative examination method is desirable because CT requires higher X-ray dose levels. Tomosynthesis (TS) involves acquiring a few dozen cross-sectional images per acquisition, which requires lower X-ray dose levels than CT.

2. Purpose

To evaluate corrective loss of intra-articular dislocation by TS after locking plate surgery for intra-articular fractures.

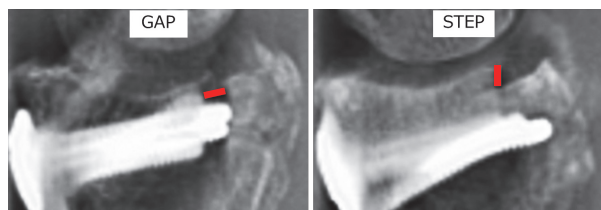
3. Applicable Cases and Methods

In 68 of the 89 cases involving locking plate surgeries (one DVR-1, 18 Acu-Loc 2 proximal, 35 Acu-Loc 2 distal, and 14 Variax plates) for intra-articular fractures performed at the hospital between May 2015 and September 2017, follow-up observations were made using TS and Xp one day after the surgery (on average 1.2 ± 1.3 days, ranging from 0 to 2 days after) and 12 weeks after the surgery (on average 87.0 ± 11.6 days, ranging from 74 to 105 days after). The male to female ratio was 22:46 and the mean age was 62.0, with a standard deviation of ± 15.0 (16 to 88).

Excluded cases include one case with repeated surgeries involving multiple fractures and an open fracture, and 20 cases where TS was not performed. The number of required samples was 62⁶⁾ given the clinical significance as GAP = STEP = 0.5 mm, SD = 0.7, and Power = 0.8.

In TS images, the maximum gap and step values were measured in slices where the intra-articular dislocation appeared the greatest in lateral and frontal views (Fig. 1).

In Xp images, the radial inclination (degrees), ulnar variance (mm), and volar tilt (degrees) values were measured (Fig. 2).



TS Radiography/Reconstruction Parameters

Acquisition time: 5 sec.; Frontal sections: 3 to 40; Sagittal sections: 4 to 50; Slice pitch: 2 mm; Reconstruction method: FBP; and Filter: Thickness++ System used: Shimadzu fluoroscopy system

Fig.1 Example of Gap and Step Measurements by TS

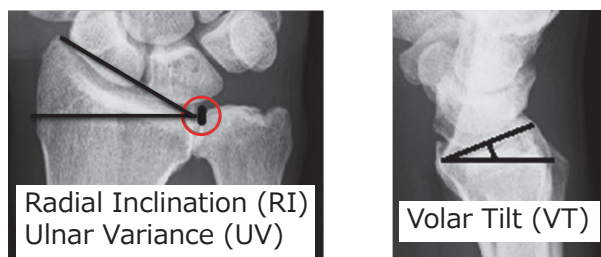


Fig.2 Example of RI, UV, and VT Measurements by Xp

4. Results

In TS evaluations, there were no significant differences in GAP or STEP values between in images acquired one day after and the ones acquired twelve weeks after surgery (Table 1). In TS images, the number of cases are three (4 %) for GAP and two (3 %) for STEP that show dislocations of 2 mm or more after one day, and one case each (1 %) after twelve weeks.

In XP evaluations, there were significant differences in UV images between one day and twelve weeks after surgery (Table 2).

Three cases are shown in Fig. 3 to 5 (a case where the fracture was retained in the reduced position without dislocation, a case where the measurement value improved due to synostosis, and a case with a deviation in the screw oriented toward the styloid process).

5. Discussion

The number of corrective loss after locking plate surgery was small in other reports listed in Table 3 or in the research. There was almost no correction loss in GAP or STEP values either.

Table 1 TS Evaluation Results

Evaluation Parameter	After 1 day	After 12 weeks	Difference	95 % CI	P-Value	
GAP (mm)	Mean Value (SD)	0.4 (0.8)	0.3 (0.6)	-0.1	-0.3 to 0.0	0.13 *
	Median Value (1st and 3rd quartile)	0.0(0.0, 0.9)	0.0(0.0, 0.6)			0.18 #
STEP (mm)	Mean Value (SD)	0.3 (0.7)	0.3 (0.5)	0.0	-0.1 to 0.0	0.47 *
	Median Value (1st and 3rd quartile)	0.0(0.0, 0.0)	0.0(0.0, 0.0)			0.70 #
Intra-Articular Screw Protrusion (number)	1	1				

* Paired t-test, # Wilcoxon rank sum test

Table 2 Xp Evaluation Results

Evaluation Parameter	After 1 day	After 12 weeks	Difference	95 % CI	P-Value
UV (mm)	0.2 (1.2)	0.6 (1.3)	0.4	0.2 to 0.6	<0.001
RI (°)	21.8 (3.0)	22.2 (2.8)	0.4	-0.1 to 0.8	0.15
VT (°)	6.7 (4.3)	6.2 (4.3)	-0.5	-1.1 to 0.3	0.21

SD indicated in parentheses Applicable t-test



Fig.3 Case with Reduced Fracture Position Maintained without Dislocation

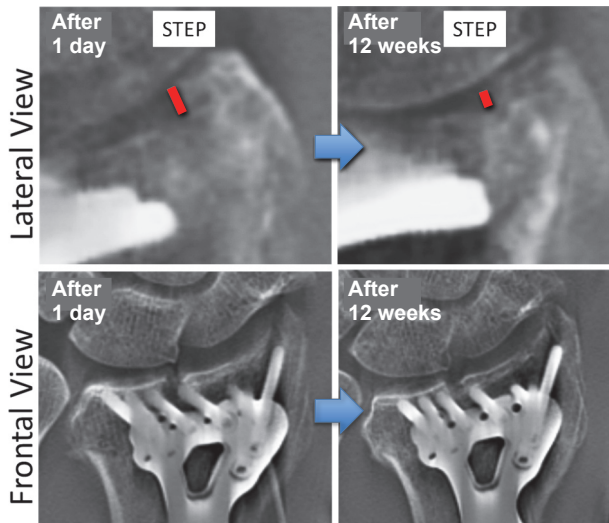


Fig.4 Case with Measurement Value Improvement Due to Synostosis

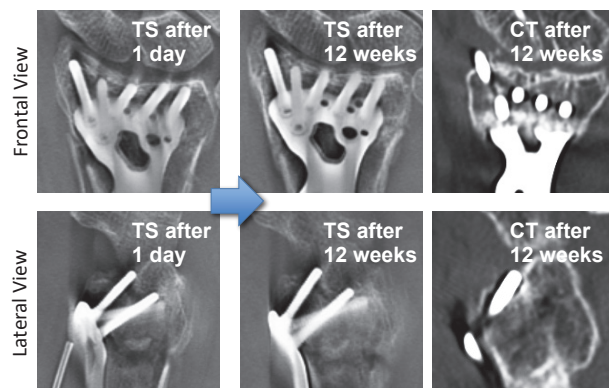


Fig.5 Case with Deviated Screw Oriented toward Styloid Process

A benefit of TS is minimal affection by metal artifacts, while providing diagnostic accuracy equivalent to CT for intra-articular discontinuities⁶⁾. Furthermore, TS requires lower X-ray dose levels than CT (19.8 mGy for CT versus 0.72 mGy for TS)⁹⁾. In contrast, TS fracture diagnostic accuracy is superior to Xp but inferior to CT⁷⁾.

The reliability of CT measurements by Yamazaki et al. is indicated in Table 4. The reliability of TS measurements was determined based on the inter-rater reliability of evaluations one day after surgery. That reliability level was moderate-to-substantial, as shown in Table 5.

Table 3 Correction Loss after Locking Plate Surgery for a Fracture of the Distal Radius^{2),3),4)} Compared to the Given Research

	Cases	Evaluation Timing	UV (mm)	RI (°)	VT (°)	GAP (mm)	STEP (mm)
Kawasaki	49	20M	0.8	0.8	0.5		
Stone	268	6W		0	0		
Neuhaus	364	3M	0.7	1	1.2		
This Research	69	3M	0.4	0.4	0.5	0.1	0.0

Less than clinical significance (0.5 mm) in this research

Table 4 CT Measurement Reliability

CT Measurement Reliability for Intra-Articular Dislocations ⁸⁾	
Gap ICC (2.1)	: 0.91 (0.85-0.94)
STEP	: 0.90 (0.84-0.93)

Table 5 TS Measurement Reliability

Evaluation Parameter	ICC (2.1)	95% CI	P-Value	Landis Classification	
ICC (1.2)	GAP	0.89	0.83~0.93	<0.01	almost perfect
	STEP	0.79	0.68~0.87	<0.01	substantial
ICC (2.1)	GAP	0.57	0.38~0.71	<0.01	moderate
	STEP	0.54	0.35~0.69	<0.01	moderate

Limitations of this research include a lack of a diagnostic gold standard (true intra-articular dislocation values determined by CT, for example), selection bias in the 21 unexamined cases (24 %), and the unknown effects (intra-articular dislocation) of synostosis after 12 weeks.

6. Summary

There was good reduced position retention within joints up to twelve weeks after locking plate surgery for intra-articular fractures. The results suggest TS provides utility for intra-articular evaluation after surgery.

References:

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