Percutaneous screw fixation without bone graft for cystic-type scaphoid fractures

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With the development of new screws for scaphoid fractures, union rate have risen to 94%[1] or 84%[2] even in non-union cases. There is still some controversy concerning whether bone graft is necessary for cystic type non-union. Although the most popular classification system of scaphoid fractures is Filan and Herbert's classification[3], there is no expression of cystic lesions in this classification, and it is not useful for determining a treatment strategy. Therefore, we propose a new classification system of scaphoid non-unions based on radiographic findings, such as linear type, cystic type, and sclerotic or displaced type[4]. This classification system is useful for designing a treatment strategy, so we expanded this classification system to acute scaphoid fractures (Fig. 1). The purpose of this study is to explain our treatment strategy based to our new classification system for scaphoid fractures and to demonstrate that bone graft is not necessary for cystic type fractures.

PATIENTS AND METHODS

We retrospectively studied the 105 scaphoid fractures (Table 1) of 94 male and 11 female patients ranging in age from 14 to 67 years (average, 26 years). The radiograms were taken of the following views: posteroanterior, lateral wrist, scaphoid (posteroanterior in ulnar deviation), and oblique with 45 degrees to 60 degrees of pronation[5]. Bone union was estimated from all 4 views. There were 12 proximal pole fractures and 93 waist fractures. We omitted tubercle fractures from this study and defined acute fractures as injury happened less than 2 months before surgery, and delayed fractures as more than 2 months. There were 48 acute fractures and 57 delayed fractures. The reason why we had more delayed fractures than acute fractures was that the delayed fracture patients were referred to us in our area. We classified the scaphoid

fractures depending on radiographic findings; linear type, cystic type, and sclerotic or displaced type (Fig. 1). The linear and cystic types did not have any displacement more than 2 mm. If the fracture line had a sclerotic zone thicker than 1 mm, it was classified as a sclerotic or displaced type. There were 51 linear types, 24 cystic types, and 30 sclerotic or displaced types. There were no acute sclerotic or displaced type fractures. There were 6 delayed linear fractures and 21 delayed cystic type fractures. We used the Herbert screw from 1988 to 1997, the AO 3.0 mm cannulated screw from 1998 to 2002, and the Acutrak screw from 2003 to 2006. There were 34 patients in the Herbert group, 43 in the AO group, and 28 in the Acutrak group. We used the Acutrak mini screws for 7 linear cases and 2 cystic cases, 6 sclerotic or displaced cases in the Acutrak screw group. The other 13 cases were used Acutark standard screws. For proximal pole fractures, we used the Herbert mini or Acutrak mini screws. The treatment strategy for linear type was percutaneous screw fixation only and for sclerotic or displaced type was open reduction and block iliac bone graft with screw fixation. The treatment strategy for cystic type was mixed; screw fixation without bone graft for 17 cases and screw fixation with cancellous bone graft for 7 cases.

The period until bone union of selected waist fractures, which radiograms were taken periodically, was compared between the types. There were 26 linear cases, 12 cystic cases, and 14 sclerotic or displaced cases. An ultrasound signal was applied to the last 4 cystic waist fracture cases in the Acutrak group. Pulsed low-intensity ultrasound consisted of 1.5 MHz ultrasound wave pulsed at 1kHz with 20% duty cycle at an intensity of 30 mW/cm^2 spatial average temporal average[6]. The ultrasound was applied for 20 minutes per day until bone union was achieved. Data were expressed as mean

(SD). Scheffe's test was used to evaluate the significance of differences among the types of fractures. Probabilities of less than 0.05 were accepted as significant.

CASE 1: A 21-year-old male involved in a traffic accident and had wrist injury. He visited our hospital 2 months after the injury and the radiographic examination revealed a scaphoid fracture (Fig.2-A). This scaphoid fracture was classified as cystic type. At that time, we planned an open approach and screw fixation with bone graft. The intraoperative view showed no displacement, no defect, and no instability at the fracture site (Fig.2-B). Therefore, instead of bone grafting, I decided to only insert an Acutrak mini screw (Fig.2-C). Bone union was achieved three months after the surgery (Fig.2-D).

CASE 2: A 16-year-old female who received wrist injury while playing handball. She visited our hospital 8 months after the injury and the radiographic examination revealed a cystic type scaphoid non-union (Fig.3-A). We performed a percutaneous screw fixation without bone graft (Fig.3-B). Bone union was achieved five months after the surgery (Fig.3-C).

CASE 3: A 24-year-old male with a wrist injury from being involved in a traffic accident. He had surgery at a different hospital and visited our hospital 5 years later. We did not have any information from the previous surgery, but the radiographic examination revealed a scaphoid non-union (Fig.4-A). After removing the screws from the earlier surgery, this non-union was classified as cystic type with no instability using an image intensifier (Fig.4-B). We decided on a percutaneous screw fixation without bone graft using an Acutrak standard screw (Fig.4-C). Bone union was achieved 3 months after the surgery (Fig.4-D).

CASE 4: A 17-year-old female who received a wrist injury through a fall during running. She visited our hospital 1 month after the injury and the radiographic examination revealed cystic type proximal pole scaphoid fracture (Fig.5-A). We used an only percutaneous Acutrak mini screw fixation without bone graft. Bone union was achieved three months after the surgery (Fig.5-B).

RESULTS

There were 6 failure (bone union was not achieved) cases in total (Table 1). Since none of the patients complained of wrist pain even radio graphically non-union, they did not want additional surgery. Therefore, the total union rate in this series was 94%. There was one failure case of a cystic delayed fracture without bone graft in the Herbert group. There were 5 failure cases in the AO group: 3 cystic delayed fractures, one with bone graft and 2 cases without bone graft, and 2 delayed sclerotic or displaced fractures. There were no failure cases in the Acutrak group. In 12 proximal pole fractures, there were no failure cases. In 48 acute fractures, there were no failure cases. In 57 delayed fractures, there were 6 failure cases; union rate of this series was 89%. In 51 linear fractures, there was no failure case. There were 4 failure cases in cystic type, with a union rate of 83%. There was one failure in 7 cases with bone graft (85%) and 3 failures in 17 cases without bone graft (82%). There were two failure cases in sclerotic or delayed type out of 30 cases, with a union rate of 93%.

The average periods until bone union for waist fractures were as follows (Fig. 6); 2.3 months (SD 0.60) in linear type (26 cases), 3.5 months (SD 1.1) in cystic type (12 cases), and 3.7 months (SD 0.91) in sclerotic or delayed type (14 cases). There was a significant difference between linear type and cystic type ($p=0.0004$), and sclerotic or

delayed type ($p<0.0001$). There was no significant difference between cystic and sclerotic or displaced type. In the last 4 cases out of 12 cystic fractures, bone union was achieved with ultrasound application. Average bone union period for the last 4 cases with ultrasound was 3.3 months (SD 0.49) and for the 8 cases without ultrasound was 3.6 months (SD 1.3). There was no significant difference between two groups ($p=0.62$).

DISCUSSION

One method for classifying scaphoid fractures is based on the length of time between the injury and treatment, utilizing the terms; acute, delayed, or non-union. Treating non-union is more difficult than treating acute fractures[7], because the fracture line is sclerotic or the fracture site is displaced and angular deformity started. Hence, the length between injury and treatment is considered to be very important. However, there are also some linear type fractures in delayed cases. In our study, there were 6 cases of linear type even two months after the injury. We achieved bone union for these 6 cases using percutaneous screw fixation without bone graft. If there is no displacement and sclerotic change at the fracture site (our linear type), the length between injury and treatment is not important factor to decide the treatment strategy.

In the previous study, percutaneous screw fixation to the acute fracture was performed[8]. The indication of percutaneous screw fixation in their report could be considered the equivalent of our linear acute fracture. They achieved bone union in an average of 2.6 months in 11 cases[8]. Since we achieved bone union in an average of 2.3 months in 26 cases including delayed cases, the results are almost the same. Another authors defined the fibrous union as; sclerotic line is less than 1 mm thick and alignment is correct[9], which could be considered the equivalent of our linear delayed

fracture. Percutaneous screw fixation was tried to 15 cases of their fibrous union[9]. They achieved bone union in all cases in an average 3.5 months[9]. According to these previous papers[8, 9], our strategy for linear fractures without consideration of the length of time between the injury and treatment, using a percutaneous screw fixation without bone graft, was demonstrated to be proper.

In sclerotic or displaced type, there were no acute fractures in our seriese. Hence, sclerotic or displaced type could be considered the equivalent of delayed or non-union fracture in other reports. The union rate for bone grafting the scaphoid non-union of the 5246 cases reviewed was 84%[2]. There were only 2 failure cases (89% union rate) in our series, our result was excellent compared to previous studies[1, 2]. We had 8 sclerotic or displaced proximal pole fractures. All cases achieved bone union. However, the union rate of the proximal pole non-union was poorer than that of the waist fractures as 78%[2]. Since our series did not include osteonecrosis of proximal pole fractures, our results were favorable. Iliac block bone graft for angulated displaced scaphoid fractures was the standard method[5, 10]. Hence, our strategy for sclerotic or displaced fractures, using screw fixation with iliac block bone graft, was proven correct.

Cystic lesion is considered to be a characteristic of delayed or non-union[10]. However, there were 3 cystic type cases even in acute fractures in our series. Hence, the length between injury and treatment is not important to decide treatment strategy. We could not decide whether using bone graft or not in cystic cases, because there have been no studies indicating clearly. There were some reports which examined cystic appearance of scaphoid fractures[10, 11]. The category of “cyst formation and sclerosis”,

which showed bone resorption at non-union interface, cyst formation, and maintained scaphoid alignment, could be considered the equivalent of our cystic type[10]. They recommended bone graft for this category. In addition, the other report recommended curettage and filling with small cancellous bone chips in cystic defects[11]. We could not agree with bone graft for cystic fractures from our results, because the union rate of our cystic types between bone grafting cases (85%) and non-bone grafting cases (82%) had no difference. In addition, according to intraoperative view of Case 1, cystic lesion does not always indicate defect or instability at the fracture site. Considering the 100% union rate in the Acutrak group of the 10 cystic fractures including 7 delayed cases, bone graft was not necessary for cystic type even in delayed cases when we use the Acutrak screws.

The difficulty in treating cystic fractures is the delay of bone union. The period for bone union in cystic type was no different from that of sclerotic or displaced type, which required bone graft (Fig. 6). Bone union for cystic type was significantly longer than that of linear type in our study. For this reason, we have recently, applied ultrasound waves to cystic type to promote earlier union[6]. The period of bone union improved an averaged 0.4 months after applying ultrasound waves, even though there was no statistical significance. We will survey more cases and investigate the improvement of cystic type bone union using ultrasound in a future study.

CONCLUSIONS

Our new radiographic classification does not consider the length between injury and treatment in scaphoid fractures and indicates a treatment strategy of; percutaneous screw fixation without bone graft for linear type; screw fixation with iliac

block bone graft for sclerotic or displaced type; and percutaneous Acutrak screw fixation without bone graft using ultrasound wave application just after the surgery for cystic type.

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REFERENCES

1. Munk B, Larsen CF. Bone grafting the scaphoid nonunion. *Acta Orthop Scand* 2004; 75:618-629.
2. Merrell GA, Wolfe SW, Slade JF. Treatment of scaphoid nonunions: quantitative meta-analysis of the literature. *J Hand Surg* 2002; 27A:685-691.
3. Filan SL, Herbert TJ. Herbert screw fixation of scaphoid fracture. *J Bone and Joint Surg* 1996; 78B:519-529.
4. Ikeda K, Itoh T, Takashi H, et al. Treatment plan for delayed and non-union of the scaphoid fracture. Kossetsu 2006; 28 (in Japanese): 94-98.
5. Trumble TE, Salas P, Bartbel T, et al. Management of scaphoid nonunions. *J Am Acad Orthop Syrg* 2003; 11: 380 - 391.
6. Parvizi J, Vegari D. Pulsed low-intensity ultrasound for fracture healing. *Foot and Ankle Clincs* 2005; 10:595-608.
7. Brooks S, Wluka AE, Stuckey S, et al. The management of scaphoid fractures. *J Sci Med Sport* 2005; 8:181-189.
8. Chen ACY, Chao EK, Hung SS, et.al. Percutaneous screw fixation for unstable scaphoid. *J Trauma* 2005; 59: 184-187
9. Slade JF, Geissler WB, Gutow AP, et al. Percutaneous internal fixation of selected scaphoid nonunions with an arthroscopically assisted dorsal approach. *J Bone and Joint Surg* 2003; 85A:20-32.
10. Slade JF, Dodds SD. Minimally invasive management of scaphoid nonunions. *Clinic Orthop Rel Res* 2006; 445:108-119.
11. Eggli S, Fernandez DL, Beck T. Unstable scaphoid fracture nonunion: a

medium-term study of anterior wedge grafting procedures. *J Bone and Joint Surg* 2002; 27B:36-41.

Figure legends

Fig. 1 The classification of scaphoid fractures

We classified scaphoid fracture depending on the radiographic findings, as linear type, cystic type, and sclerotic or displaced type. The length between injury and treatment is not considered in this classification. The linear and cystic types do not have any displacement more than 2 mm. If the fracture line has sclerotic zone thicker than 1 mm, it is classified to the sclerotic or displaced type.

Fig. 2 Case 1: 21-year-old male

A: Two months after injury, the radiographic examination shows a cystic type scaphoid fracture.

B: An intraoperative view shows no displacement, no defect, and no instability at the fracture site.

C: An Acutrak mini screw is inserted.

D: Bone union is achieved three months after surgery.

Fig. 3 Case 2:16-year-old female

A: 8 months after injury, radiographic shows a cystic type scaphoid fracture.

B: Percutaneous Acutrak mini screw fixation without bone graft is performed.

C: Bone union is achieved five months after surgery.

Fig.4 Case 3: 24-year-old male

A: 5 years after the former surgery

B: After removing the former screws, this non-union is classified as cystic type.

C: Percutaneous Acutrak standard screw fixation without bone graft is performed.

D: Bone union is achieved 3 months after surgery.

Fig. 5 Case 4: 17-year-old female

A: One month after injury, the radiogram shows cystic type proximal pole scaphoid fracture.

B: Acutrak mini screw fixation without bone graft is performed and bone union is achieved 3 months after surgery.

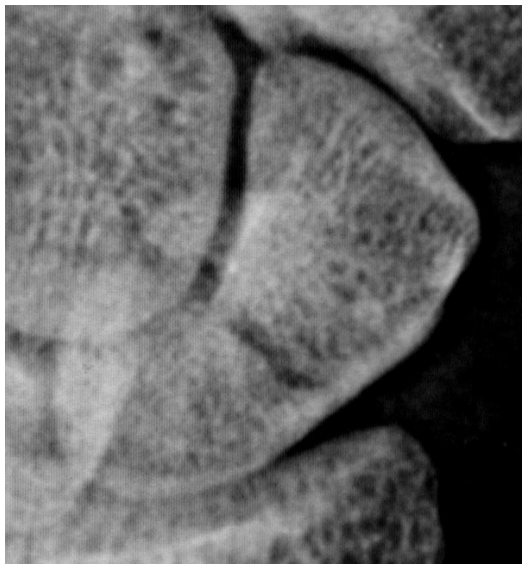
Fig. 6 Period until bone union is achieved.

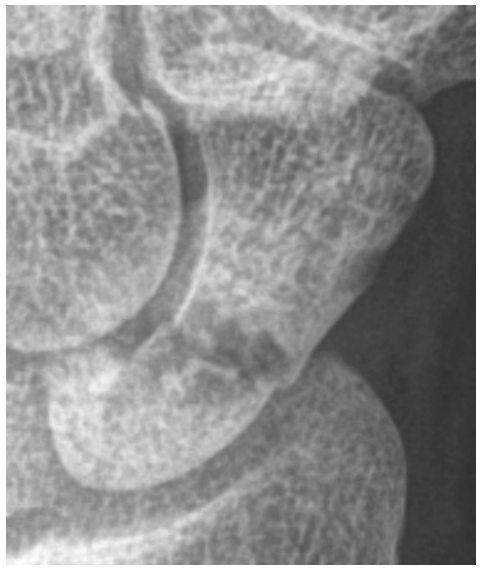
There is a significant difference between linear type and cystic type ($p=0.0004$), and sclerotic or delayed type ($p<0.0001$). There is no significant difference between cystic and sclerotic or displaced type.

Table 1. Number of patients with scaphoid fractures

Types of scaphoid fracture \ Types of screw		Herbert screw 1988~1997		AO 3.0mm cannulated screw 1998~2002		Acutrak screw 2003~2006		Sum.
		Acute	Delayed	Acute	Delayed	Acute	Delayed	
Linear	Prox.	0	1	0	0	0	1	51(0)
	Waist	18	1	16	3	11	0	
Cystic	Prox.	0	0	0	0	2	0	24(4)
	Waist	0	With Bone graft: 1 / Without Bone graft: 4 (1)	0	With Bone graft: 6(1) / Without Bone graft: 3(2)	1	7	
Sclerotic or Displaced	Prox.	0	7	0	0	0	1	30(2)
	Waist	0	2	0	15(2)	0	5	
Sum.		34(1)		43(5)		28(0)		105(6)

( ): Failure cases Acute < 2 months ≦ Delayed ▭: With bone graft



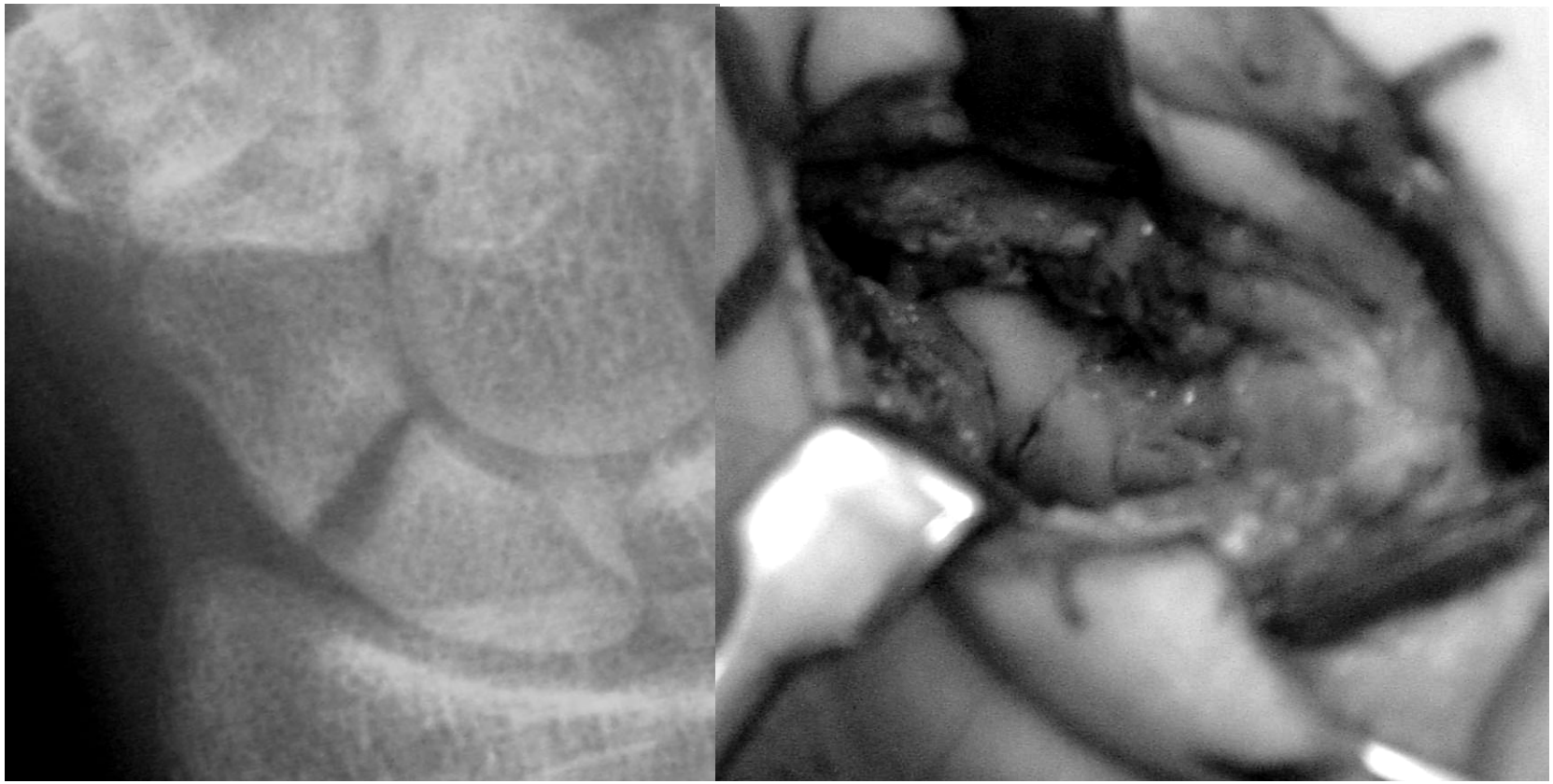


Linear type

Cystic type

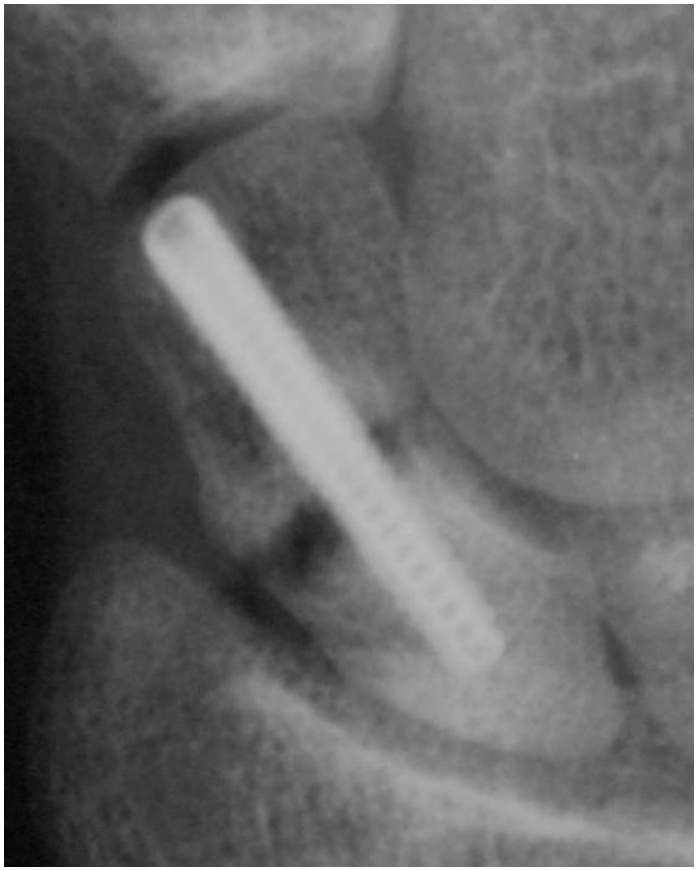
Sclerotic or Displaced type

Figure 1



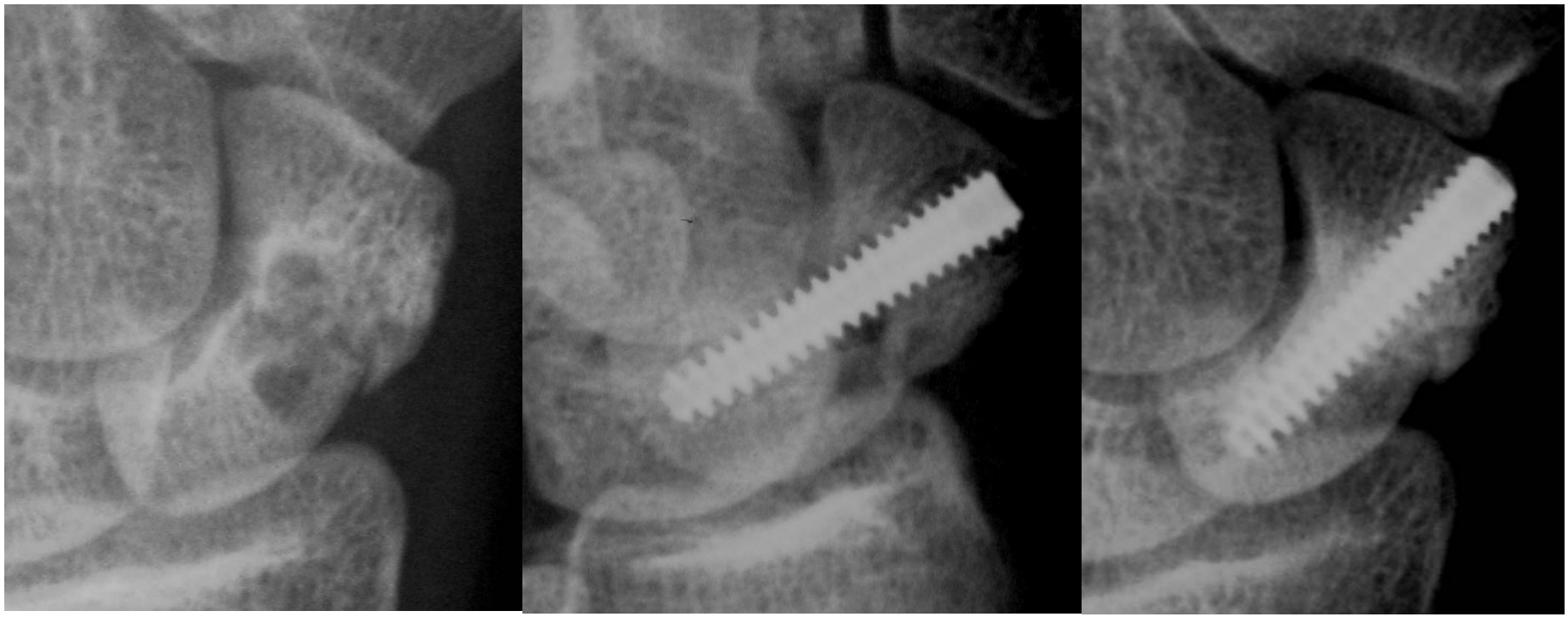
A **B**

Figure 2



C **D**

Figure 2

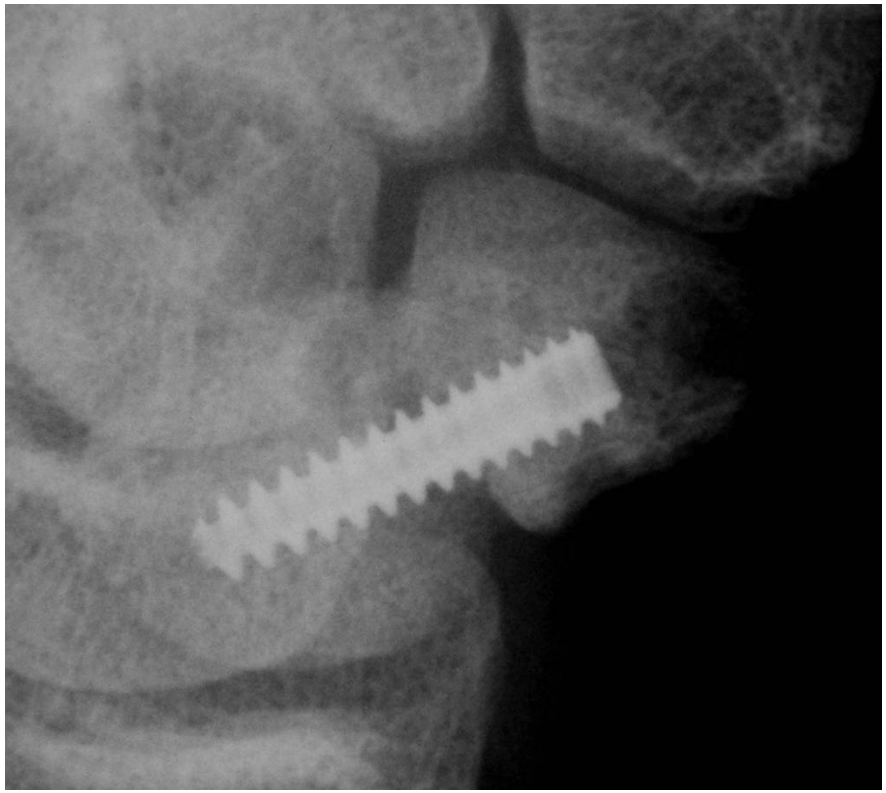


A **B** **C**

Figure 3

A **B**

Figure 4



C **D**

Figure 4

A **B**

Figure 5

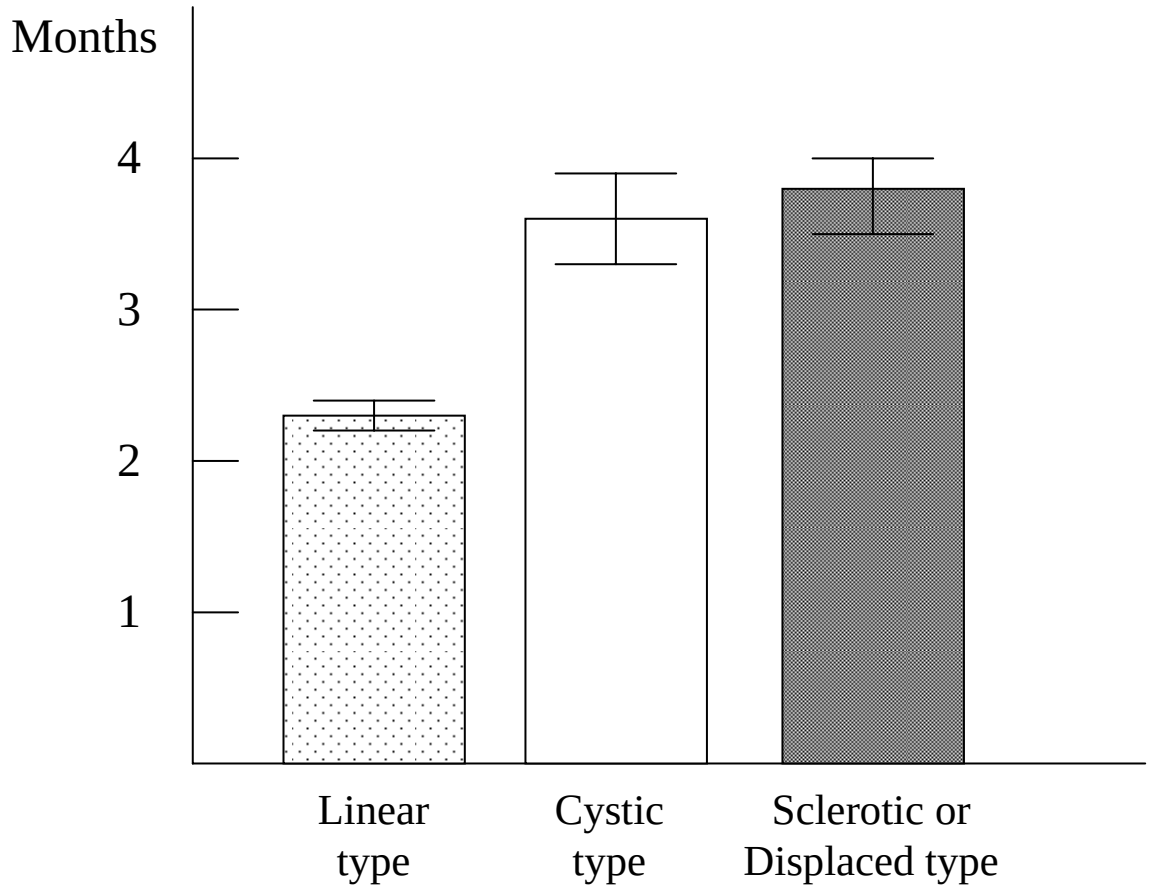

Months
4
3
2
1
Linear type
Cystic type
Sclerotic or Displaced type

Figure 6