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Treatment of Proximal Humeral Fracture Using Polarus Nail and Philos Plate

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Background: To compare the treatment of the proximal humerus fracture using a Polarus nail or Philos plate, we aimed to analyze the functional recovery and the factors affecting the selection between the two types of surgery.
Methods: The study included 107 patients with proximal humerus fracture who underwent surgery at our institution. Of these patients, 67 underwent surgery with Polarus nails (G1) and 40 with Philos plates (G2). In G1, the cases of two- and three-part fractures were 60 and 7 cases, in G2, the cases of two-, three-, and four-part fractures were 28, 10, and 2 cases, respectively. The average age was 61 years old, and the average follow-up period was 32.5 months. We compared radiological results, the functional recovery retrospectively.
Results: The radiological union time was 6.8 weeks and 8.7 weeks on average in G1 and G2 ($p < 0.05$). At the one-year follow-up period, these were visual analogue scale (VAS) 1.355, forward flexion (FF) 130.968, external rotation (ER) 50.161, internal rotation (IR) L2 in G1, and VAS 0.781, FF 135.806 ER 51.25, IR L1 in G2, respectively, showing no significant differences between the two groups ($p > 0.05$). Similar observations were made at the final follow-up. In terms of functional recovery, no significant differences were seen at the one-year or at the final follow-up period ($p > 0.05$).
Conclusions: For the surgical treatment of proximal humeral fracture, the selection of the type of surgery is affected by the fracture pattern. However, both methods give satisfactory outcomes and do not show significant differences in the functional outcome after the surgery.
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Key Words: Proximal humeral fracture; Polarus nail; Philos plate

Introduction

The proximal humerus fracture comprises of approximately 5% of all fractures, and in particular, this rate is increasing in the aged.[1] Approximately 80% of the proximal humerus fractures are nondisplaced and stable fractures, and can be mainly treated by conservative treatment with good results. However, in cases of unstable fractures, anatomical reduction and fixation by surgical means, along with early functional recovery of the joint in known to be important.[2] The determining factors for the surgical treatment of the proximal humerus fracture are when it is accompanied by open fracture, damage to the blood vessels or nerves, or when the displaced fracture is unable to be reduced.[2,3] There are a variety of surgical techniques that are used for the treatment including the use of plates, K-wire fixation, tension band technique, suture anchor fixation, intramedullary nailing and so on.[4] However, the practical difficulties of these surgery techniques, the failure of fixation, reduction loss, malunion and non-union, subacromial impingement, humeral head avascular necrosis are just few examples of a variety of complications that occur.[2,4] Polarus nails and Philos plates were introduced to counteract these complications, and their strengths include their ability for a stable fixation, limited complications, as well as the possibility of starting early joint motion exercise.[5-10] Under the assumption that both types of the surgery gives the same satisfactory results, the authors used both methods to treat proximal

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humerus fractures, comparing the radiographical and functional outcomes, as well as analyzing the factors affecting the selection of the type of surgery.

Methods

A retrospective study was carried out including 107 patients with proximal humerus fracture who had received surgery at our hospital between June 2003 and December 2012. Of these 107 patients, 67 underwent surgery with Polarus nail (G1) and 40 with Philos plate (G2). Prior to surgery, medical information of all study subjects were recorded in full, including their age, sex, underlying disease, mechanism of injury, and accompanying orthopedic injury etc. Furthermore, the fracture of each patient was categorized according to the Neer classification of proximal humerus fracture by simple radiology. The inclusion criteria for the participants were those that had undergone surgery within 2 weeks of obtaining injury and those with either two-, three-, or four-part fracture according to Neer classification. The exclusion criteria were those with fractures that could affect the selection of surgery type or affect the outcome of surgery, such as the accompaniment of ipsilateral upper limb fracture, or those with open fracture, fracture with damage to the blood vessel, and pathological fracture. Using both the preoperative radiological assessment as well as imaging during surgery, cases in which closed reduction and fixation was deemed possible were allocated to surgery with Polarus nail. On the other hand, cases deemed requiring anatomical reduction and a stable fixation were allocated to surgery by open reduction with Philos plate. After surgery, the bone union period and neck-shaft angle were determined by simple radiology, and the patient's degree of pain, range of motion (forward flexion, external rotation and internal rotation), and other functional assessments (Korean Shoulder Society scores [KSS scores], University of California at Los Angeles scores [UCLA scores], Constant scores, American Shoulder and Elbow Surgeons scores [ASES scores]) were determined at 2 weeks, 4 weeks, 3 months, 6 months, and one-year after surgery. In G1, the cases of two-part and three-part fractures were 60 and 7 cases, respectively. In G2, the cases of two-, three-, and four-part fractures were 28, 10 and 2 cases, respectively. The number of males and females were 28 and 39 in G1, and 17 and 23 in G2, respectively. The average age was 61 years (range: 17−89 years), and the average follow-up period was 32.5 months (range: 12 months−9.5 years). We analyzed the factors affecting the selection between the two type of surgeries, and radiologically assessed the postoperative bone union period, union pattern and the degree of functional recovery by retrospective comparison. Data were analyzed using IBM SPSS Statistics ver. 19.0 program (IBM Co., Armonk, NY, USA). The statistical methods used were two sample t-test, repeated measure two-factor analysis, and ANOVA, with $p < 0.05$ accepted as statistically significant.

Results

The underlying disease was similar for both groups. The common mechanisms of injury were slip down, traffic accidents, and fall. The number of cases for each mechanism was 41 (61%), 14 (20.8%), and 8 (11%) cases in G1, respectively, and 18 (45%), 19 (47.5%), and 2 (5%) cases in G2, respectively (Table 1). Polarus nails were usually used in the patients with lower category of Neer classification, and similar results were seen even when adjusted by age and underlying disease ($p < 0.05$) (Table 2). The period of bone union was earlier in G1, occurring on average at 6.79 weeks in G1, and 8.65 weeks in G2 ($p < 0.05$) (Table 3). The length of surgery was shorter in G1, on average 63 minutes in G1, and 113 minutes in G2 ($p < 0.05$). Determined as a ra-

Table 1. Underlying Disease, Injury Mechanism, and Accompanying Damage in Each Group

	Polarus nail (n)	Philos plate (n)
Underlying disease		
Hypertension	14	10
Diabetes mellitus	10	7
Cerebrovascular accident	5	
Dementia	2	
Liver disease	2	
Herniated nucleus pulposus	1	2
Parkinson disease	1	
Osteoporosis	3	
Gastric ulacer disease	1	
Congestive heart failure	1	2
Injury mechanism		
Slip down	41	18
Fall down	8	2
Rolling down	2	
Traffic accident	14	19
Sports injury		1
Heavy burden		1
Unknown	2	
Accompanying damage		
Clavicle fracture	3	2
Sacral body fracture	1	
Ankle fracture	1	3
Scapular body fracture		1
Tibia fracture	1	

diological index at the final follow-up, the the neck-shaft angle was on average 145.791° (standard deviation [SD] 8.044) in G1, and 138.500° (SD 12.602) in G2. The neck-shaft angle for all patients was within normal range when compared with that of the unaffected side, which is 142°. Of the patients, 48 cases had medial calcar injury, and the average neck-shaft angle in the corresponding groups was 140.189° (SD 11.138). On the other hand, the average for those without the medial calcar injury was

Table 2. Comparison of the Neck-Shaft Angle by Displacement on the Medial Calcar

Neer classification	Group		F (*p*-value)
	Polarus nail	Philos plate	
None	2.104 ± 0.308	2.350 ± 0.580	8.185 (0.005)*
Age	2.098 ± 0.308	2.361 ± 0.580	8.886 (0.004)*
Underlying	2.103 ± 0.308	2.352 ± 0.580	8.229 (0.005)*
Age, underlying	2.098 ± 0.308	2.361 ± 0.580	8.794 (0.004)*

Values are presented as mean ± standard deviation.
*Statistically significant with $p < 0.05$.

Table 3. Comparison of Union Time by Group

Variable	Group		t (*p*-value)
	Polarus nail	Philos plate	
Union time (wk)	6.79 ± 1.606	8.65 ± 2.167	3.032 (0.003)*
Operation time (min)	63.433 ± 15.477	113.375 ± 27.160	-10.644 (0.000)*
Age (yr)	64.37 ± 19.24	55.98 ± 15.39	7.056 (0.084)

Values are presented as mean ± standard deviation.
*Statistically significant with $p < 0.05$.

Table 4. Comparison of the Neck-Shaft Angle by Group

	Group		t (*p*-value)
	Polarus nail	Philos plate	
Neck-shaft angle (˚)	145.791 ± 8.044	138.500 ± 12.602	3.282 (0.002)*

Values are presented as mean ± standard deviation.
*Statistically significant with $p < 0.05$.

Table 5. Comparison of the Neck-Shaft Angle by Displacement on Medial Calcar

Variable	Displacement on medial calcar		t (*p*-value)
	Present (n = 48)	Absent (n = 59)	
Neck-shaft angle-last follow-up (˚)	140.189 ± 11.138	144.586 ± 9.973	-2.082 (0.040)*

Values are presented as mean ± standard deviation.
*Statistically significant with $p < 0.05$.

Table 6. Comparison of the Range of Motion (FF, ER, and IR) by Time, Group, and Time Group*

Variable	Group	Time						F (*p*-value)		
		2 wk	6 wk	3 mo	6 mo	12 mo	Last follow-up	Time	Group	Time group*
FF	Polarus nail	57.016 ± 12.658	82.581 ± 12.923	100.968 ± 24.002	117.742 ± 25.762	130.968 ± 24.609	138.064	534.480 (0.000)*	0.052 (0.819)	8.135 (0.000)*
	Philos plate	66.774 ± 17.774	74.839 ± 20.309	96.129 ± 30.296	120.645 ± 26.825	135.806 ± 24.190	140.313			
ER	Polarus nail	23.871 ± 4.911	25.484 ± 7.169	35.323 ± 10.514	44.355 ± 12.755	50.161 ± 11.087	56.612	307.651 (0.000)*	0.027 (0.870)	1.752 (0.138)
	Philos plate	20.625 ± 4.878	24.844 ± 5.606	35.313 ± 10.772	45.781 ± 11.853	51.250 ± 11.846	57.500			
IR	Polarus nail	2.328 ± 1.106	2.393 ± 1.215	3.000 ± 1.538	4.148 ± 1.750	5.541 ± 1.911	5.726	261.785 (0.000)*	15.723 (0.000)*	14.068 (0.000)*
	Philos plate	2.281 ± 0.813	3.188 ± 1.306	4.531 ± 1.459	6.000 ± 1.320	6.688 ± 1.491	6.852			
VAS	Polarus nail	6.952 ± 0.688	4.984 ± 0.558	3.065 ± 0.721	1.387 ± 0.491	1.355 ± 0.482	1.048	1251.945 (0.000)*	2.235 (0.138)	13.674 (0.000)*
	Philos plate	6.281 ± 0.924	4.875 ± 0.871	3.250 ± 0.950	1.844 ± 0.677	0.781 ± 0.792	1.000			

Values are presented as mean ± standard error or mean.
FF: forward flexion, ER: external rotation, IR: internal rotation, VAS: visual analogue scale.
*Statistically significant with $p < 0.05$.

144.586° (SD 9.973), showing a significant difference ($p < 0.05$) (Table 4, 5).

Up until 3 months from surgery, the degree of pain and the range of motion were on average visual analogue scale (VAS) 3.065, forward flexion (FF) 100.968, external rotation (ER) 35.323, internal rotation (IR) L4 in G1, and VAS 3.25, FF 96.129, ER 35.313, IR L3 in G2, respectively, showing greater improvement in G1 than in G2. However, at the one-year follow-up period, these were VAS 1.355, FF 130.968, ER 50.161, IR L2 in G1, and VAS 0.781, FF 135.806, ER 51.25, IR L1 in G2, respectively, showing no significant difference between the two groups ($p > 0.05$). Similar observations were made at the final follow-up (Table 6, Fig. 1).

The functional assessments of both groups were carried using the KSS scores, Constant scores, UCLA scores, and ASES scores. The scores at 3 months and one-year after surgery were KSS scores 60.742, 85.758, Constant scores 32.032, 53.194, UCLA scores 18.935, 31.774, and ASES scores 19.548, 29.452 in G1 and KSS scores 61.156, 86.594, Constant scores 32.063, 53.188, UCLA scores 19.000, 31.906, and ASES scores 19.781, 29.500 in G2. The results showed no significant difference ($p > 0.05$) and similar patterns were seen at the final follow-up (Table 7, Fig. 2).

Complications in G1 were 9 cases of screw fullout and 2 cases of reduction loss, whilst in G2 there were 2 cases of reduction loss and one case of metal failure. The 9 cases of screw fullout did not have an effect on bone union.

Discussion

Proximal humerus fracture that is severely displaced or insecure must be treated by surgical means, and there are several reported methods. However, a consensus agreeing on how to choose between these methods is yet to be made.[5-7] The current trend can be largely identified as the use of proximal nails and compression plate fixation, which are both improvements to the preceding methods.[8,9,11,12] Therefore, the authors used representative techniques of each method, the Polarus nail and Philos plate, respectively. Following surgical treatment, the authors compared the radiological and functional outcomes so as to be able to determine the key factors in choosing the most effective surgery method. Kim et al.[13] reported that in displaced proximal humerus fractures, Philos plate is a useful technique for fixation that also gives satisfactory results. Rajasekhar et al.[14] carried out

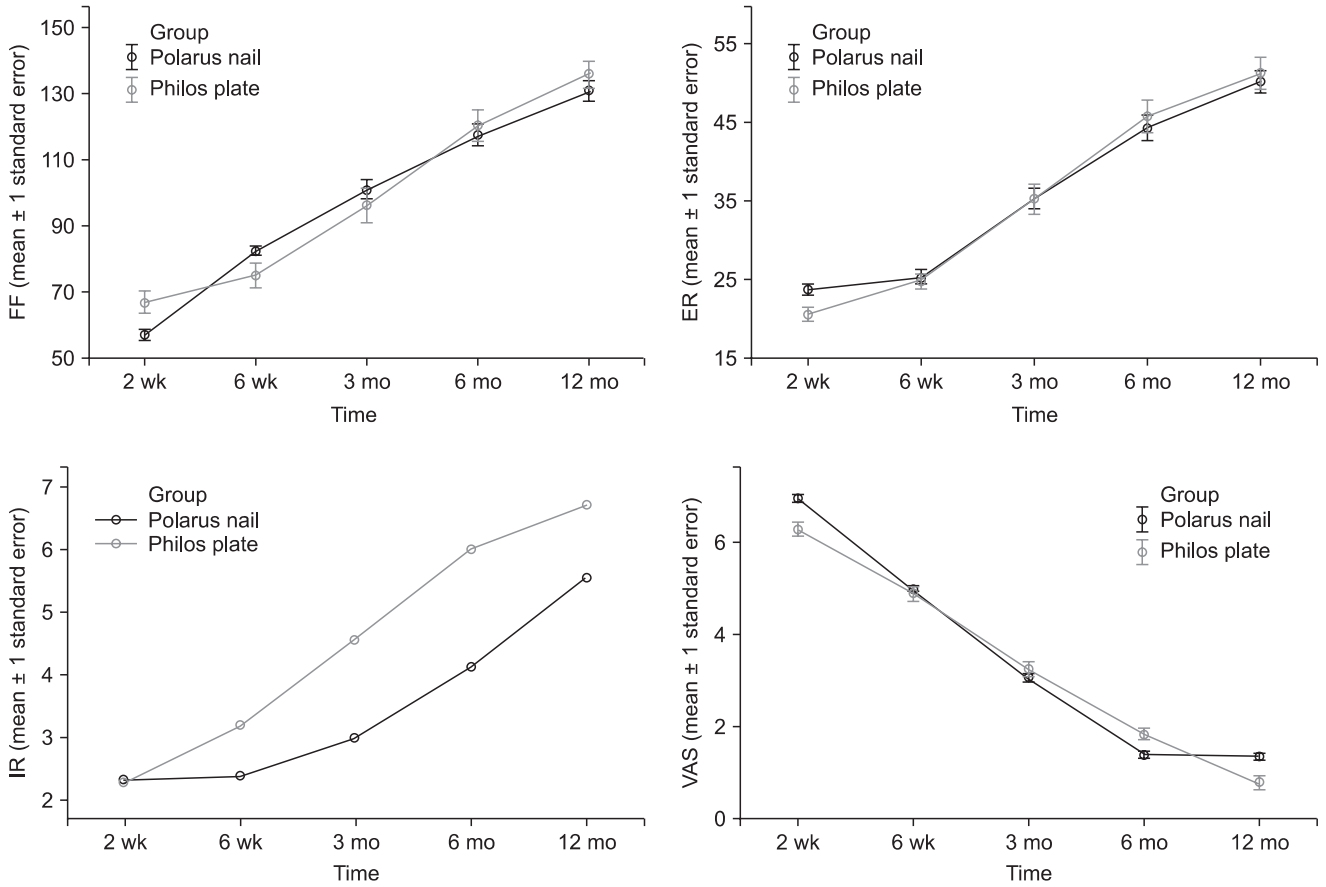

Fig. 1. Graph showing the range of motion (FF, ER, IR, VAS) against time by group. FF: forward flexion, ER: external rotation, IR: internal rotation, VAS: visual analogue scale.

Table 7. Comparison of KSS, UCLA, Constant, and ASEA by Time, Group, and Time Group*

Variable	Group	Time						F (*p*-value)		
		2 wk	6 wk	3 mo	6 mo	12 mo	Last follow-up	Time	Group	Time group*
KSS score	Polarus nail	40.984 ± 5.193	50.629 ± 3.255	60.742 ± 3.506	75.742 ± 3.426	85.758 ± 4.497	87.750	4,225.619 (0.000)*	1.526 (0.220)	0.806 (0.522)
	Philos plate	42.719 ± 5.101	51.281 ± 3.829	61.156 ± 3.960	76.656 ± 3.199	86.594 ± 4.471	86.951			
UCLA score	Polarus nail	7.242 ± 1.596	14.516 ± 1.647	18.935 ± 3.228	24.468 ± 1.376	31.774 ± 2.944	32.596	2,112.078 (0.000)*	1.919 (0.169)	4.630 (0.001)*
	Philos plate	8.719 ± 1.631	15.781 ± 1.431	19.000 ± 3.282	23.969 ± 1.425	31.906 ± 2.900	32.687			
Constant score	Polarus nail	12.871 ± 0.839	19.065 ± 1.567	32.032 ± 2.247	43.000 ± 8.224	53.194 ± 2.194	53.741	1,416.879 (0.000)*	0.030 (0.862)	0.073 (0.990)
	Philos plate	12.844 ± 0.723	19.156 ± 2.886	32.063 ± 2.299	42.500 ± 9.284	53.188 ± 2.177	53.562			
ASES score	Polarus nail	7.387 ± 1.464	14.758 ± 1.905	19.548 ± 2.895	24.355 ± 1.450	29.452 ± 0.899	29.741	2,572.268 (0.000)*	2.673 (0.105)	13.474 (0.000)*
	Philos plate	9.844 ± 2.034	14.875 ± 1.897	19.781 ± 2.254	23.750 ± 1.295	29.500 ± 1.016	29.687			

Values are presented as mean ± standard error or mean.
KSS score: Korean Shoulder Scale score, UCLA score: University of California at Los Angeles scores, ASES score: American Shoulder and Elbow Surgeons score.
*Statistically significant with $p < 0.05$.

Polarus nail in 30 cases of proximal humerus fractures and found satisfactory outcomes in 80% of the patients. Similarly, Crolla et al.[15] carried out Polarus nail and saw a fusion rate of 100% in 30 cases of acute fracture, and a fusion rate of 66% in 9 cases of malunion. Nayak et al.[16] studied 17 patients and saw an improvement in the UCLA shoulder score by 17.6 points, from an average of 4.4 points before surgery to 22 points afterwards. In another study, Kim et al.[17] compared the surgical outcome from using a Philos plate, which is currently under spotlight as providing a stronger fixation, and an unlocked plate, and saw that neither the neck-shaft angle, bone union nor the Constant score was significantly different, but complications were fewer and the strong fixation allowed the early start of joint motion exercise, thus more useful. However, a comparative study reporting the use of Polarus nail and Philos plate is sparse. Of the existing literature, Lekic et al.[18] studied 24 cases of proximal humerus two-part fractures, in which compression plate fixation and intramedullary nailing both made in satisfactory results. Konrad et al.[19] studied 211 cases of proximal humerus three-part fracture, in which the proximal nailing and compression plate groups showed similar results, concluding that both techniques were useful. However, they also reported limitations to their study, being the lack of comparison between two-part and three-part fractures.

Of the cases of proximal humerus fractures that were deemed to require surgery, the authors used Polarus nail for cases requiring close reduction and fixation, and used Philos plate for those needing anatomical reduction and a stronger fixation. Even if the authors had previously agreed on using Polarus nail, there is some degree of flexibility during the surgery. For instance, if the reduction was unsatisfactory at the moment of surgery, i.e. when the closed reduction was unsatisfactory during surgery, the surgery was changed to open reduction with Philos plate. Generally, Polarus nail was mainly used to treat two-part fractures (89%), and Philos plate was used to treat three-part and greater fractures (30%). The mechanism of injury and their relative frequencies were slightly different between the two groups. In G1, the injuries were from 41 cases of slip down (61%) and 14 cases of traffic accidents (20.8%), whilst the order was reversed in G2 at 19 cases of traffic accidents (47.5%) and 18 cases of slip down (45%). The frequency of slip down and traffic accident cases is relatively evenly distributed in G2, and this is reflected by higher number of injuries from greater trauma. Accompanying orthopedic injuries were 9 cases (13%) in G1 and 10 cases (25%) in G2, and this higher frequency in G2 is also thought to be due to the higher composition of traffic accidents in injury. If the mechanism of injury involves a high amount of energy, the risk of accompanying damage and bone spicules increases. This is in accordance with the above result that fractures of larger Neer classifications were treated with Philos plate (Table 1, 2). The neck-shaft angle measured at the final follow-up was slightly

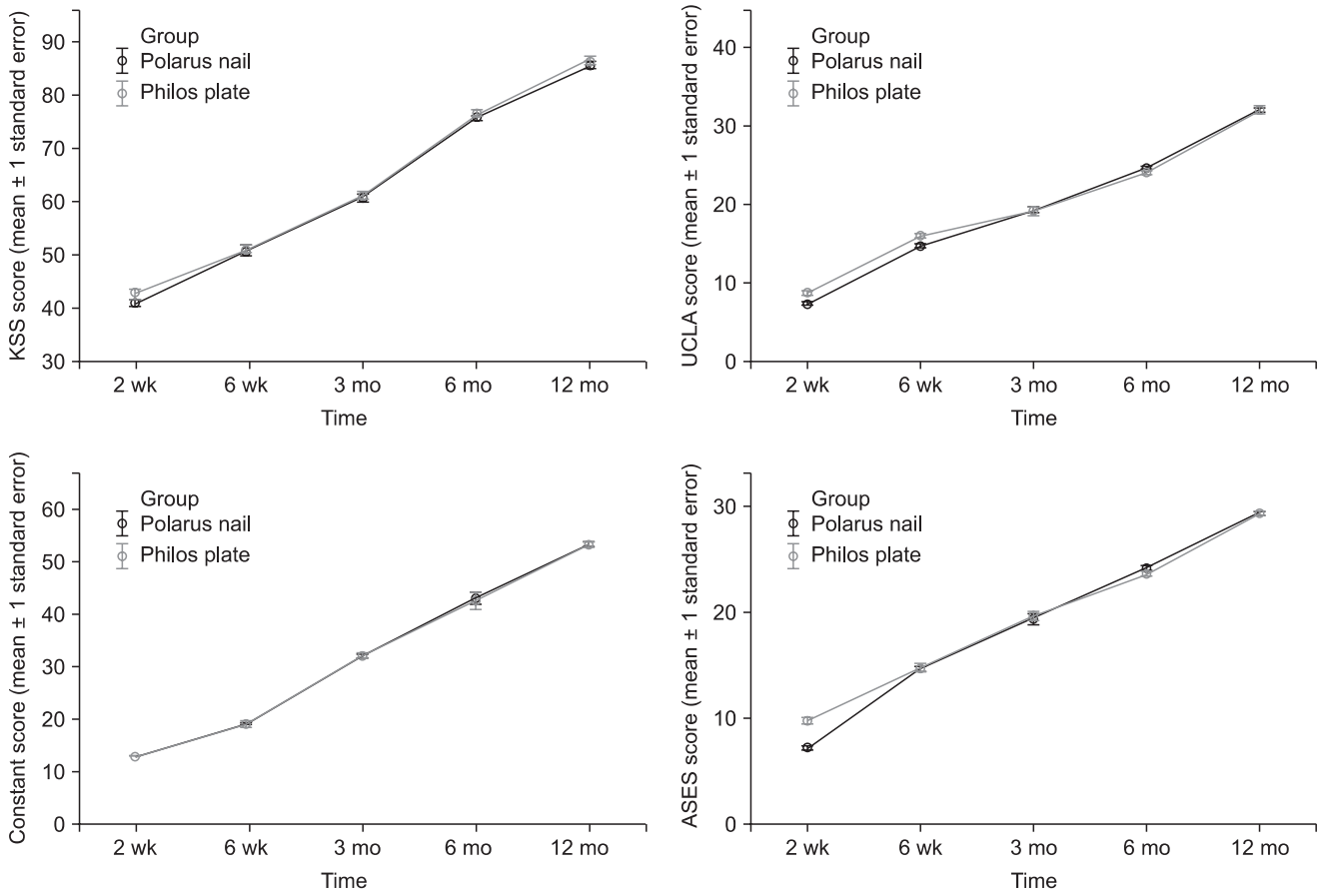

Fig. 2. Graph showing KSS score, UCLA score, Constant score, and ASES score against time by group. KSS score: Korean Shoulder Scale score, UCLA score: University of California at Los Angeles scores, ASES score: American Shoulder and Elbow Surgeons score.

greater in G1, on average 145.79° (SD 8.044), than in G2, on average 138.5° (SD 12.602), but the angle in both groups was within normal range when compared with the unaffected side. We suspect the reason for this is that since Polarus nail is difficult to be achieved by closed reduction, it becomes fixed at a state of valgus impaction. Preoperative radiological assessment revealed that 48 patients had medial calcar injury, of which 27 were in G1 and 21 were in G2.The average neck-shaft angle in their respective patient groups were 140.18° (SD 11.138), whilst the average neck-shaft angle in the patient group without medial calcar injury was 144.58° (SD 9.973). The average neck-shaft angle after surgery in the presence of medial calcar injury indicates increased tendency of varus, but was still within normal range. Similarly, Ponce et al.[20] used locked plates to treat proximal humerus fracture and reported tendencies of varus in the presence of medial calcar injury, but also that this tendency could be decreased by recovering the calcar with a screw.

The period of bone union was different between the two groups, on average 6.79 weeks (SD 1.606) and 8.65 weeks (SD 2.167) in G1 and G2, respectively ($p < 0.05$). However, it is inappropriate to make such a simple comparison as the surgical treatment of fracture was different. The average age at the time of injury was 64.37 years old in G1, and 55.98 years old in G2. This indicated that the Polarus nail tended to be used in older people ($p = 0.084$), but was not statistically significant. The length of the surgery was significantly shorter in G1, which is thought to be related to the undertaking of closed reduction and fixation. This may be a positive factor in that it may reduce the morbidity rate after surgery. We found that in the surgical treatment of the proximal humerus fracture, the factors that affect the selection of the type of surgery included fracture pattern, injury mechanism, accompanying damage, and age. Of these, only the fracture pattern was statistically significant. The fracture pattern is believed to have a strong relationship with the fact that the selection of the type of surgery was based on the the viability of closed reduction assessed before surgery.

At present, there is a lack of comparative studies on the use of Polarus nail and Philos plate in the surgical treatment of proximal humerus fracture, as well as the determing factor of treatment choice. There are several limitations to our study, which include the retrospective aspect of the study in which the surgical cases of G1 and G2 were compared retrospectively. Also, there is a

difference in the average age and underlying disease in the two groups. Furthrmore, the fracture pattern varied with the mechanism of injury and the degree of injury, which means that there is high chance of selection bias. Also, there was a lack of a preoperative statistical analysis on the demography of the patients, as well as the conventional limitations of clinical trials that restrict the randomized selection of patients. Despite these limitations, we find that our sudy has meaning in that we tried to identify the pre-operative factors that affect the selection of the type of surgery. We aim for further investigation by making adjustments to the variables of the two study groups, thus investigating the clinical effects of each adjustments in terms of selecting the type of surgery.

Conclusion

For the surgical treatment of the proximal humerus fracture using either a Polarus nail or Philos plate, the selection of the type of surgery is affected by the fracture pattern. However, both methods give satisfactory outcomes and do not show significant differences in the degree of pain, range of motion, or functional outcome after the surgery.

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