

Aaro Heinonen

**SORMEN DISTAALISEN
INTERFALANGEAALINIVELEN JA
PEUKALON INTERFALANGEAALINIVELEN
ARTRODEESIN LUUTUMISEEN
VAIKUTTAVAT TEKIJÄT**

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Aaro Heinonen, Olli Leppänen, Heini Huhtala, Teemu Karjalainen, Jarkko Jokihara: Sormen distaalisen interfalangealinivelen ja peukalon interfalangealinivelen artrodeesin luutumiseen vaikuttavat tekijät
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Tutkimuksen tarkoitus. Tutkimuksessa selvitettiin tekijöitä, joiden oletettiin vaikuttavan luutumiseen sormen distaalisen interfalangeaali- (DIP) ja peukalon interfalangealinivelen (IP) artrodeesissä eli luudutusleikkauksessa.

Aineisto ja menetelmät. Aineisto sisälsi kaikki Tampereen yliopistollisessa sairaalassa vuosina 2007-2016 suoritettut sormen DIP- ja peukalon IP-nivelen artrodeesit. Analysoitavat muuttujat määriteltiin etukäteen ja tiedot kerättiin potilaskertomusjärjestelmästä. Sekä potilaaseen (ikä, sukupuoli, tupakointi, diabetes, reumatauti, indikaatio) että operaatioon (fiksaatiomenetelmä, luupintojen muotoilutapa, antibiootti, immobilisaatioaika, kirurgin kokemus) liittyviä tekijöitä verrattiin yksi- ja monimuuttuja-analyyseissa tulosmuuttujiin, joita olivat normaali luutuminen, ei luutumista, infektio ja re-operaatio eli uusintaleikkaus.

Tulokset. 310 operaatiosta 280 johti artrodeesiin ja 30 niveltä ei luutunut seurannassa. Suurin osa muuttujista ei ennustanut toimenpiteen lopputulosta. Yksimuuttuja-analyysissä luutumattomuuden suurin ennustaja oli kirurgin kokemus. Verrattuna erikoislääkəriin, erikoistuvan lääkäriin suorittamana artrodeesi johti useammin luutumattomuuteen (OR=3.75, 95 % CI=1.73-8.14, P=0.001) ja re-operaatioon (OR=4.71, 95% CI=1.56-14.2, P=0.006). Erikoistuvan ja erikoislääkäriin potilasjoukoissa ei ollut eroja. Luutumattomuuteen johtavien artrodeesien pienen lukumäärän takia monimuuttuja-analyysia ei voitu suorittaa luutumattomuudelle. Monimuuttuja-analyysissä reumatauti oli yhteydessä viivästyneeseen luutumiseen.

Johtopäätökset. Sormen kärkinivelen artrodeesi tuottaa yleensä oletetun tuloksen riippumatta useista potilaaseen tai toimenpiteeseen liittyvistä tekijöistä. Tulokset painottavat riittävän kokemuksen merkitystä yksinkertaisenkin kirurgisen operaation onnistumisessa.

Avainsanat: artrodeesi, sorminivel, re-operaatio.

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Factors Influencing Bone Union in Finger Distal Interphalangeal and Thumb Interphalangeal Joint Arthrodesis

Abstract

Background: Finger joint arthrodesis is a common operation which has many indications including acute trauma, post traumatic condition, osteoarthritis, and rheumatoid joint deformity. The objective of this study was to evaluate factors which may influence bone union in arthrodesis of the distal interphalangeal (DIP) joint of the fingers and interphalangeal (IP) joint of the thumb.

Methods: A total of 310 arthrodesis (221 finger DIP and 89 thumb IP joint) were analysed retrospectively. We used variables related to the patient and to the operative technique in univariable and multivariable regression analysis. Outcome events were bone union within 90 days, established non-union, infection and re-operation.

Results: Of the 310 operations 280 resulted in a favourable outcome while 30 resulted in bone non-union. In the univariable analysis the most important negative predictor variable for bone non-union was an operation done by other than hand surgery specialist (OR=3.75, 95% CI=1.727-8.140, P=0.001), which also predicted the indication for re-operation (OR=4.705, 95% CI=1.563-14.163, P=0.006). Because of insufficient event rate of bone non-union multivariable analysis was not possible for bone non-union. In the multivariable analysis rheumatoid arthritis had negative influence on bone union within 90 days (OR=0.45, 95% CI=0.219-0.925, P=0.03) and none of the variables predicted infection.

Conclusions: In our cohort finger DIP and thumb IP joint arthrodesis generally resulted in favourable outcome in terms of bony union regardless of the underlying medical condition or technical details of the surgical operation. Overall the results emphasize the importance of adequate surgical skill and practice even with a simple surgical operation.

Introduction

Finger distal interphalangeal (DIP) or thumb interphalangeal (IP) joint arthrodesis is usually performed in order to relieve pain, correct deformity or stabilize a dysfunctional joint. Causes for such symptoms include acute traumatic or post-traumatic condition, osteoarthritis, and rheumatoid arthritis.¹⁻⁷⁾

Three most common bone fixation methods in DIP and thumb IP joint arthrodesis are Kirchner wires, headless compression screws and Kirchner wire with interosseous Cerclage wire. There are studies which compare different bone fixation techniques and in a recent systematic review bone union rates in DIP joint arthrodesis ranged from 91% to 96%.¹⁻⁷⁾ Fixation with headless compression screw has been associated with slightly higher bone union rates but it increases the risk of some minor complications, and currently there is no consensus of the best fixation technique.¹⁻⁷⁾ Data on other factors which may affect bone union in DIP arthrodesis is scarce even though arthrodesis is a well-established operation. Patient related factors such as smoking⁸⁾, diabetes^{9, 10)} and rheumatoid¹¹⁾ arthritis may influence the outcome. Regarding technical aspects of arthrodesis, proper resection of subchondral bone in the operation has been emphasized.^{12, 13)}

Our hypothesis was that patient characteristics and technical details of the surgical operation influence bone union in finger DIP or thumb IP joint arthrodesis. Accordingly, the objective of this study was to evaluate which variables increase the probability of a non-union after an arthrodesis. The results could provide data to support clinical decision making when assessing treatment options for individual patients.

Methods

This study was a retrospective cohort study. We identified all DIP joint and thumb IP joint arthrodesis operations performed between 1/2007 and 12/2016 at a university hospital. The consecutive patient cohort was obtained from the hospital records. All patients were included in the study and full medical records were reviewed for data collection. The minimum follow-up was 1 year and if the follow-up was incomplete the patient was excluded from the cohort. The study was conducted according to the instructions of the Institutional Review Board of the Hospital District.

Predictor variables were categorized into two groups: 1) variables related to the patient and 2) variables related to the surgical operation. Patient-related factors included sex, age, body mass index (BMI), smoking, working, diagnosis of diabetes or rheumatic disease, type of operation (elective or emergency surgery), whether it was the first arthrodesis operation of that joint (primary arthrodesis: the first operation for the joint; re-arthrodesis: a new arthrodesis was performed after a failed arthrodesis; secondary arthrodesis: if arthrodesis was performed after some other type of joint surgery), and which hand and finger was operated. Operation-related variables included bone fusion surface resection technique, bone fixation technique, whether Kirchner wires were cut short and buried under skin or left longer over skin in order to facilitate removal, use of peri- and post-operative antibiotics, post-operative immobilisation time, and surgeons' experience. If operating surgeon had completed hand surgery speciality training he/she was considered experienced while hand surgery residents or fellows were considered less experienced. If some detail in patient records was missing or ambiguous it was recorded as not available (NA).

The outcome variables were: bone union within 90 days, established non-union, infection and re-operation. Normal bone union was defined as a clinical and radiological confirmation of bone union within 90 days of the surgery. We were unable to determine exact time to bone union or define a group of patients with delayed bone union because the time points for follow up visits were not uniform. Established non-union was defined by confirmed absence of bone union during the follow-up. Re-operation was recorded if a subsequent operation of any type (new arthrodesis or salvage) was indicated and performed after an arthrodesis operation. Infection included superficial or deep infection at the surgical site at any time point during the follow-up.

Univariable logistic regression analyses were used to calculate odds ratios (OR) for the following outcome binary variables: bone union within 90 days, established non-union, infection and re-operation. Univariable analysis was calculated for all predictor variables. For the multivariable model, in order to reduce the number of predictor variables we included only variables which were a priori hypothesised to have most clinical relevance. These variables included: sex, age, smoking, rheumatoid arthritis, diabetes, elective vs. emergency operation, surgeon experience, bone resection method, fixation method, and immobilization time. Nevertheless, we were able to perform multivariable logistic regression analyses only for bone union within 90 days and infection, because the number of outcome events was not sufficient for multivariable model of established non-union and re-operation. We did not perform stepwise regression analysis because of possible overfitting bias. Results are reported with the corresponding 95% confidence intervals (95% CI) and P-value < 0.05 was considered statistically significant. All statistical analyses were performed using SPSS version 23 (IBM, NY, USA).

Results

A total of 335 finger DIP or thumb IP joint arthrodesis operations were conducted during years from 2007 to 2016. For 25 operations we were unable to find complete follow-up data (e.g. follow-up ended prematurely because patient moved to another area) and these patients were excluded from the further analysis. A complete follow-up was available for 310 operations which included 221 finger DIP and 89 thumb IP joint arthrodesis.

The characteristics of the patients and surgical details are demonstrated in Tables 1 and 2. Fifty-two per cent of the patients were female, and the mean age was 59.3 years for the female patients and 50.5 years for the male patients. The average BMI was available for 282 patients (average BMI 25.7, standard deviation 4.3). Of the total 310 operations 222 were elective and 88 were operated as emergency operations, and 84 of the 88 emergency operations were performed to males. In contrast, elective operation was more frequent with females as 146 of the total 222 elective operations were performed to females. Most common diagnosis among the elective patients were osteoarthritis (n=78) and rheumatoid arthritis (n=64). The distribution of operations by digit in different indications is presented in Figure 1. Overall the distribution between right and left hand was almost equal (right hand operated in 53%), but right hand was slightly more often operated if the indication was osteoarthritis (63%) or rheumatoid arthritis (56%), and slightly less often operated in acute trauma (40%) and post traumatic conditions (47%) when compared with left hand. Twenty-four per cent of the patients were not employed (retired or unemployed) at the time of the operation, but because of substantial missing data (n=72, 23%) this variable was excluded from the further analysis.

The most common fixation methods were two Kirchner wires or a headless compression screw. In the emergency operations Kirchner wire fixation alone was used in 78 of the 88 operations and Kirchner wires with interosseous Cerclage wire in 6 of the 88 operations (Figure 2). Overall, the average immobilization time was 43 days (with Kirchner wires and with screw fixation on average 46 and 36 days, respectively). Use of single perioperative antibiotic dose was common among emergency operations (100%) and patients with rheumatoid arthritis (89%), while postoperative prophylactic antibiotic was mainly used for trauma patients (74%). Majority of the patients were operated by a hand surgery specialist (n=212, 68%). There were no significant differences in any of the patient-related or operation-related variables between the patients operated by a hand specialist or by other surgeons. The proportion of specialist surgeons was similar in emergency and elective operations.

Ninety per cent (n=280) of the operations resulted in favourable outcome during the clinical follow-up. In these patients, radiological determination of bone union within 90 days was observed in 179 operations and 101 operations resulted in clinically stable and painless outcome, but without the specific radiological determination of bone union at the final follow up visit. An established radiological non-union was observed in 30 (10%) patients. An infection was observed in 50 (16%) patients and 47 of these were minor superficial infections while 3 were reported as more severe deep infections. Fixation with Kirchner wires led to infection in 39 cases (36 superficial and 3 deep) which comprised 18% of all Kirchner wire fixations, and fixation with headless compression screw led to 8 superficial infections which comprised 10% of all screw fixations. Usage of Kirchner wires with Cerclage led to 2 infections. Fifteen re-operations (5%) were performed and these were all re-arthrodesis surgeries. There were no salvage or other types of re-operations.

In the univariate analysis (Table 3) bone union within 90 days was observed more often after elective operations when compared with acute trauma surgery (OR 1.7, CI 95% 1.0-2.8, P=0.040). The use of headless compression screw as the fixation method was positively associated with bone union within 90 days and negatively associated with bone non-union. The most important predictor for bone non-union was operation by other than hand surgery specialist (OR 3.8, CI 95% 1.7-8.1, P=0.001), which also predicted the need for re-operation (OR 4.7, CI 95% 1.6-14.2, P=0.006). Regarding infections, only increased BMI was correlated with surgical site infection, but however, none of the infected wounds resulted in arthrodesis non-union.

In the multivariable regression analyses (Table 4) rheumatic disease had a negative influence on bone union within 90 days. None of the variables was associated with infections in the multivariable model. We were unable to perform multivariable logistic regression analyses for bone non-union and re-operation, because the rate of these outcome events was not sufficient.

Discussion

In this retrospective evaluation of 310 finger DIP or thumb IP joint arthrodesis most of the evaluated variables were not associated with favourable or unfavourable outcomes. The strongest predictor of non-union was surgeon's lack of speciality training which resulted in almost four-fold risk. Regarding all the other patient characteristics, diagnosis of rheumatoid arthritis was associated with decrease rate of established bone union within 90 days, but there were no other individual significant associations between the underlying patient characteristics in the multivariable model. These findings almost entirely refute our hypothesis of the influence of patient characteristics and surgical details on the outcome.

Fixation method did not predict bone union in multivariate analysis. A variety of operative techniques has been developed for the bone fixation in the DIP and thumb IP arthrodesis including Kirschner wire, many types of screws and rods, and Cerclage wire, and previous studies have reported higher union with headless screw fixation but these studies did not adjust for confounding factors.^{1-7,13)} In accordance with previous studies, in our study union rates achieved with headless compression screws were slightly higher when compared with Kirchner wire fixation in univariable analysis, but there were no differences in the multivariable analysis. Inclusion of confounding variables in the analysis is crucial, because for example, Kirchner wire fixation is common in emergency joint arthrodesis operations, whereas compression screws are mostly used in elective operations. And when considering the type of operation, bone union within 90 days was more probable in elective surgeries than in emergency surgery in univariate analysis. This may be associated with the surrounding soft tissue injury in acute trauma.

The influence of surgeon experience on the outcome even in a fairly simple operation such as DIP joint arthrodesis emphasizes the importance of adequate surgical skill and practice. It must be noted, that in this study the amount of experience was based only on the presence of hand surgery specialist credentials. It has been demonstrated that there may be a disparity in the distribution of operations during hand surgery training¹⁴⁾ but we did not use the number of arthrodesis operations per surgeon because this is a simple operation which all hand specialists are able to perform confidently. During the study period some of the surgeons performed operations first as a resident or fellow and then later as a hand specialist. In these cases the individual surgeons' experience status was changed accordingly during the study period.

Our finding of the negative influence of rheumatoid arthritis on bone union is in agreement with current understanding.¹¹⁾ Beldner¹³⁾ have described an increased risk of non-union in patients with diabetes in foot first metatarsophalangeal joint arthrodesis, but in our study diabetes was not associated with any outcome. Smoking has been shown to be detrimental to bone union in fracture healing,⁸⁾ but in our cohort smoking was not associated with any outcome, although the prevalence of smoking was quite high in the study cohort.

For multivariable analysis we specified the predictor variables a priori. In order to avoid model overfitting we did not use the results of univariate analysis for choosing predictor variables for multivariable regression analysis and we did not perform stepwise multivariable regression. We decided to include both acute traumatic and elective indications in order to provide for larger data for identifying possible general factors which influence the outcome, and also, to enable comparison between different indications. However, despite the relatively large number of patients in the study, we were still not able to perform multivariable logistic regression analyses for bone non-union or reoperation because the event rate of these outcomes was insufficient. BMI might have been a justified predictor variable in the

multivariable model, but it was omitted because of too much missing data. For presentation the predictor variables were classified as patient related and operation related, because in the clinical setting the former are given but the latter can usually be chosen.

Retrospective study design causes some major limitations. We were unable to reliably determine the exact time to bone union, because of several reasons: First, there is no clinically used unambiguous method for determining bone union from an x-ray image. The common clinical confirmation of successful arthrodesis outcome consists of determination of stability and absence of tenderness in the operated joint with signs of bone consolidation in the x-ray at the follow-up visit, and in our cohort the follow-up findings were not systematically described and bony union was not recorded uniformly in case notes. Second, it is not uncommon in the clinical practice to discontinue further follow-up visits before reaching the actual radiographic bone union if favourable outcome seems likely and all signs of complications are absent. Third, there was no established follow-up protocol and patients were assessed at different time points after the operation, and therefore, the time point for evaluation may have been several weeks after the actual bone union. Accordingly, we defined a category of normal bone union within 90 days in order to determine the number of operations in which the time to bone union could be considered normal, but a category of delayed bone union was not defined because the data was not accurate enough for such definition.

In future prospective studies on DIP joint arthrodesis valid primary outcome variables are crucial. The expected rate of nonunion and severe complications is low and use of those as primary outcome variables necessitates perhaps an impractically large number of study participants. Thus it might be reasonable to use other primary outcome variable – which is nevertheless important to patients – and report bone nonunion and complications as harms data.

As a conclusion, in our cohort finger DIP and thumb IP joint arthrodesis generally resulted in favourable outcome regardless of the underlying medical condition or technical details of the surgical operation. Overall the results emphasize the importance of adequate skill and practice even with a simple surgical operation. The influence of individual factors should be confirmed in future controlled trials.

References

1. Dickson DR, Mehta SS, Nuttall D, Ng CY. A Systematic Review of Distal Interphalangeal Joint Arthrodesis. *J Hand Microsurg.* 2016;06:74–84.
2. Konan S, Das A, Taylor E, Sorene E. Distal interphalangeal joint arthrodesis in extension using a headless compressive screw. *Acta Orthop Belg.* 2013;79:154–8.
3. Brutus JP, Palmer AK, Mosher JF, Harley BJ, Loftus JB. Use of a Headless Compressive Screw for Distal Interphalangeal Joint Arthrodesis in Digits: Clinical Outcome and Review of Complications. *J Hand Surg Am.* 2006;31:85–9.
4. Cox C, Earp BE, Floyd WE, Blazar PE. Arthrodesis of the Thumb Interphalangeal Joint and Finger Distal Interphalangeal Joints With a Headless Compression Screw. *J Hand Surg Am.* 2014;39:24–8.
5. Villani F, Uribe-Echevarria B, Vaienti L. Distal Interphalangeal Joint Arthrodesis for Degenerative Osteoarthritis With Compression Screw: Results in 102 Digits. *J Hand Surg Am.* 2012;37:1330–4.
6. Kocak E, Carruthers KH, Kobus RJ. Distal Interphalangeal Joint Arthrodesis with the Herbert Headless Compression Screw: Outcomes and Complications in 64 Consecutively Treated Joints. *Hand.* 2011;6:56–9.
7. Carroll RE, Hill NA. Small joint arthrodesis in hand reconstruction. *J Bone Joint Surg Am.* 1969;51:1219–21.
8. Patel RA, Wilson RF, Patel PA, Palmer RM. The effect of smoking on bone healing: A systematic review. *Bone Joint Res.* 2013;2:102–11.

9. Jiao H, Xiao E, Graves DT. Diabetes and Its Effect on Bone and Fracture Healing. *Curr Osteoporos Rep.* 2015;13:327–35.
10. Graves DT, Alblowi J, Paglia DN, O'Connor JP, Lin S. Impact of Diabetes on Fracture Healing. *J Exp Clin Med.* 2011;3:3–8.
11. Fowler JR, Baratz ME. Distal Interphalangeal Joint Arthrodesis. *J Hand Surg Am.* 2014;39:126–8.
12. Satteson ES, Langford MA, Li Z. The Management of Complications of Small Joint Arthrodesis and Arthroplasty. *Hand Clin.* 2015;31:243–66.
13. Beldner S. Arthrodesis of the Metacarpophalangeal and Interphalangeal Joints of the Hand: Current Concepts. *J Am Acad Orthop Surg.* 2016;24:290–7.
14. Silvestre J, Upton J, Chang B, Steinberg DR. The Impact of Specialty on Cases Performed During Hand Surgery Fellowship Training. *J Bone Joint Surg Am.* 2018;100:e29.

Figures

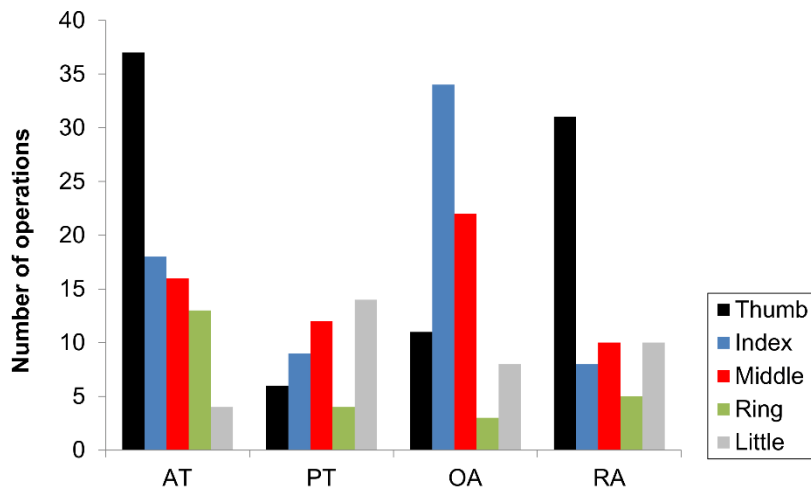


Figure 1. Operated finger (N, number of operations) by indication. AT, acute trauma; PT, post traumatic; OA, osteoarthritis; RA, rheumatoid arthritis.

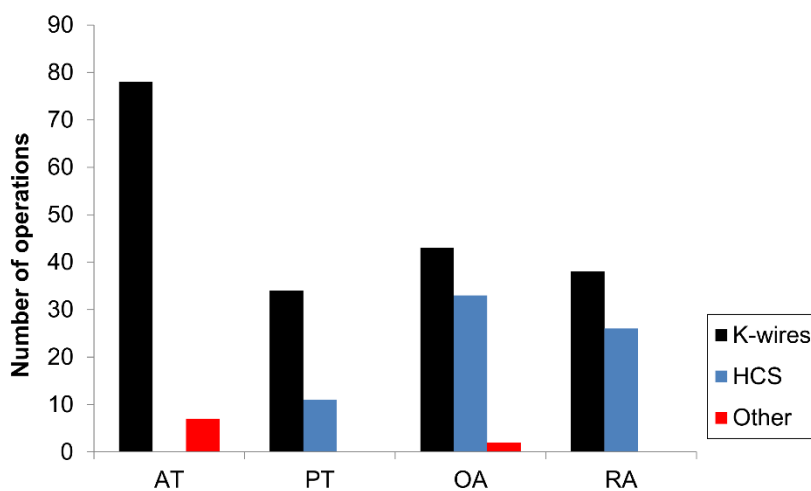


Figure 2. Fixation method (N, number of operations) by indication. K-wires, Kirchner wires; HCS, headless compression screw; AT, acute trauma; PT, post traumatic; OA, osteoarthritis; RA, rheumatoid arthritis.

Tables

		N	%
Current smoking	Yes	62	22
	No	218	78
	NA	30	
Rheumatoid	Yes	67	23
	No	224	77
	NA	19	
Diabetes	Yes	25	8
	No	277	92
	NA	8	
Indication	Acute trauma	88	30
	Post traumatic	45	15
	Osteoarthritis	78	27
	Rheumatoid arthritis	64	22
	Re-arthrodesis	18	6
	NA	17	
Hand	Right	164	53
	Left	146	47
Finger	Thumb	89	29
	Index	81	26
	Middle	67	22
	Ring	30	10
	Little	43	14

Table 1. Patient characteristics. NA, data not available.

		N	%
Perioperative antibiotic	Yes	192	62
	No	118	38
Postoperative antibiotic	Yes	100	32
	No	210	68
Fixation method	Kirchner wires	219	71
	HCS	77	25
	Kirchner wires + Cerclage	9	3
	Implant	1	0
	External fixation	1	0
	NA	3	
Kirchner wires buried	Yes	147	92
	No	12	8
	NA	60	
Hand specialist	Yes	212	68
	No	98	32

Table 2. Details of the surgical operation. HCS, headless compression screw; NA, not available.

	Bone union within 90 days			Established non-union			Infection			Reoperation		
	OR	CI 95%	P	OR	CI 95%	P	OR	CI 95%	P	OR	CI 95%	P
Patient characteristics												
Female gender	1.14	0.73-1.79	0.572	0.78	0.37-1.66	0.520	0.55	0.30-1.03	0.060	1.05	0.37-2.96	0.932
Age (y)	1.00	0.98-1.02	0.970	0.99	0.97-1.02	0.639	1.00	0.97-1.02	0.638	0.97	0.94-1.00	0.082
BMI	0.99	0.94-1.05	0.707	1.06	0.97-1.16	0.178	1.09	1.02-1.18	0.017	0.97	0.85-1.11	0.673
Current smoking	1.30	0.73-2.34	0.376	0.78	0.28-2.16	0.634	0.75	0.33-1.71	0.492	1.60	0.48-5.39	0.447
Working	1.35	0.77-2.35	0.292	1.25	0.47-3.34	0.654	0.78	0.45-1.85	0.780	1.57	0.42-5.87	0.504
Rheumatic disease	0.72	0.42-1.24	0.236	0.71	0.26-1.93	0.496	0.98	0.46-2.11	0.960	1.23	0.38-4.00	0.731
Diabetes	0.67	0.29-1.51	0.330	1.92	0.61-6.04	0.264	1.87	0.70-4.97	0.209	-		
Joint pathology												
Acute trauma	1.00			1.00			1.00			1.00		
Post traumatic	2.46	1.14-5.31	0.022	0.79	0.26-2.41	0.680	0.72	0.22-1.87	0.495	0.54	0.11-2.70	0.452
Osteoarthritis	2.39	1.26-4.54	0.008	0.62	0.23-1.68	0.350	0.38	0.15-0.98	0.044	0.31	0.06-1.51	0.146
Rheumatoid arthritis	1.13	0.60-2.16	0.704	0.42	0.13-1.38	0.152	0.64	0.27-1.53	0.311	0.37	0.08-1.86	0.229
Elective surgery	1.70	1.02-2.81	0.040	0.54	0.24-1.19	0.124	0.59	0.31-1.14	0.116	0.35	0.11-1.07	0.066
Type of operation												
Primary arthrodesis	1.00			1.00			1.00			1.00		
Re-arthrodesis	0.62	0.24-1.61	0.324	-			1.54	0.48-4.91	0.466	-		
Secondary arthrodesis	2.53	1.05-6.11	0.039	0.23	0.04-2.11	0.215	1.08	0.39-2.98	0.885	0.61	0.08-4.82	0.640
Finger												
Thumb	1.00											
Index	1.35	0.74-2.48	0.330	3.58	0.94-13.74	0.063	1.86	0.76-4.56	0.177	2.26	0.40-12.68	0.354
Middle	1.36	0.72-2.58	0.343	5.63	1.50-21.08	0.010	2.35	0.95-5.81	0.065	3.51	0.66-18.67	0.141
Ring	1.69	0.72-3.96	0.227	4.41	0.93-20.99	0.062	3.81	1.35-10.79	0.120	4.83	0.77-30.45	0.093
Little	2.03	0.95-4.34	0.069	2.15	0.42-11.12	0.361	0.91	0.26-3.15	0.884	1.04	0.09-11.75	0.977
Surgical details												
Perioperative antibiotic	0.76	0.48-1.21	0.250	0.79	0.37-1.68	0.532	1.11	0.59-2.09	0.743	0.79	0.37-1.68	0.532
Postoperative antibiotic	0.66	0.41-1.07	0.089	1.96	0.92-4.20	0.082	1.35	0.72-2.53	0.353	1.89	0.67-5.37	0.231
Other than hand specialist	0.76	0.47-1.23	0.257	3.75	1.73-8.14	0.001	1.56	0.83-2.91	0.166	4.71	1.56-14.16	0.006
Bone resection method												
Electric saw	1.00			1.00			1.00			1.00		
Chisel	0.97	0.28-3.36	0.959	-			-			-		
Rongeurs	1.18	0.74-1.90	0.488	1.05	0.48-2.30	0.901	0.70	0.38-1.30	0.257	1.22	0.41-3.67	0.720
Reamer	0.81	0.05-13.22	0.880	-			4.09	0.25-68.00	0.326	-		
Fixation method												
Kirchner wires	1.00			1.00			1.00			1.00		
Headless compression												
screw	1.97	1.13-3.44	0.017	0.21	0.045-0.90	0.035	0.54	0.24-1.20	0.130	0.21	0.03-1.62	0.134
Others	0.70	0.21-2.36	0.566	2.91	0.72-11.69	0.132	1.73	0.44-6.82	0.433	1.59	0.19-13.34	0.672
Kirchner wires buried	0.58	0.18-1.92	0.374	5.15	1.37-19.46	0.016	3.04	0.90-10.28	0.074	2.14	0.24-19.36	0.500
Immobilisation time length	1.00	0.99-1.01	0.782	1.01	0.99-1.02	0.587	1.00	0.99-1.01	0.905	1.00	0.97-1.02	0.915

Table 3. Univariate analysis for bone union within 90 days, non-union, infection, and reoperation. OR, odds ratio; CI 95%, 95% confidence interval.

	Bone union within 90 days			Infection		
	OR	CI 95%	P	OR	CI 95%	P
Female gender	1.38	0.64-2.98	0.413	1.03	0.34-3.16	0.953
Age (y)	1.01	0.99-1.03	0.512	0.98	0.95-1.01	0.138
Current smoking	1.69	0.83-3.42	0.149	0.47	0.17-1.32	0.151
Rheumatic disease	0.45	0.22-0.93	0.030	2.03	0.67-6.22	0.213
Diabetes	0.65	0.27-1.58	0.343	2.10	0.68-6.49	0.196
Elective surgery	1.61	0.70-3.69	0.259	0.33	0.10-1.10	0.071
Type of operation						
Primary arthrodesis	1.00			1.00		
Re-arthrodesis	0.43	0.14-1.32	0.140	3.50	0.79-15.58	0.100
Secondary arthrodesis	1.41	0.48-4.16	0.533	2.49	0.63-9.89	0.194
Other than hand specialist	0.88	0.53-1.48	0.638	1.61	0.83-3.13	0.161
Bone resection method						
Electric saw	1.00					
Chisel	1.01	0.29-3.55	0.988	1.00		
Rongeurs	1.18	0.71-1.95	0.520	0.69	0.35-1.33	0.264
Reamer	0.80	0.05-13.16	0.873	4.39	0.26-74.36	0.305
Fixation method						
Kirchner wires	1.00			1.00		
Headless compression screw	1.77	0.98-3.20	0.059	0.58	0.25-1.34	0.202
Other	0.64	0.19-2.17	0.468	1.59	0.39-6.44	0.515
Immobilisation time (weeks)	1.00	0.99-1.01	0.898	1.00	0.98-1.01	0.621

Table 4. Multivariable logistic regression analyses for bone union within 90 days and infection. OR, odds ratio; CI 95%, 95% confidence interval.