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ARTHRODESIS OF THE WRIST JOINT

By

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An early attempt at wrist joint arthrodesis was made by *Dubar* in 1887 using heterogenous bone graft from dog. Consolidated arthrodesis operations with autologous transplants were reported by *Spitzzy* in 1914, *Wittek* in 1914 and *Albee* in 1915. Since then a large number of varying surgical methods for wrist joint arthrodeses have been described (*Ely, Brittain, Colonna, Butler, Smith-Petersen, Abott et al., Gill*, and others).

From a functional standpoint and bearing in mind strength in closing surgical methods for wrist joint arthrodeses have been described extension with slight ulnar deviation to be the best.

Only a few authors have described resection of the ulna distally in conjunction with arthrodesis with the aim of preserving pronation and supination mobility (*Mac-Kenzie, Merle d'Aubigné & Lataste, Smith-Petersen*).

Views differ concerning whether the metacarpal joint should be included in the arthrodesis or not, but the series reported in the literature does not permit any comparative conclusions concerning the significance of the extent and technique of the arthrodesis.

THE SERIES

The series consists of 43 wrist joint arthrodeses on 42 patients, 12 women and 30 men, performed during the period 1938-1960. It was possible to analyse 42 of these arthrodeses, 35 of them during the follow-up in 1961. Of the 8 not followed-up, 3 were dead, 3 had moved abroad, 2 could not be traced, 7 of these were included in the evaluation of the results, since records and X-ray pictures made this possible.

The average observation period for the cases investigated was 8.8 years varying from 1 year to 23 years; for the 7 not followed-up it was

9.2 months. The arthrodeses were performed by 18 different surgeons. The average age of the patients at operation was 34.6 years with a range of 9 years to 58 years.

Etiologically the series consists of:

- 8 polio-pareses,
- 3 post-traumatic pareses,
- 2 spastic pareses,
- 9 rheumatic polyarthritides,
- 14 post-traumatic arthroses:
 - 5 radial fractures
 - 3 navicular fractures
 - 2 luxations,
 - 4 laceration injuries
- 6 lunatomalacias

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In paralyses the operation indications consisted in reduced function, in polyarthritides cases the indications were pain on movement and aching and also in a number of cases reduction in function owing to volar flexion contracture. With lunatomalacias and the post-traumatic arthroses pain on movement and aching were also the main indications and in one case it was the wish for a more attractive position.

OPERATIVE PROCEDURE

Autologous material was used in all 36 bone graft operations. Bone transplantation from the radius to the base of metacarpal III was carried out in 26 cases, 9 of which were combined with denudation of the cartilage radio-carpally and inter-carpally and 5 with a wedge osteotomy radio-carpally. The graft was taken in 15 cases from the tibia, in 9 cases from the iliac crest and in 2 cases from the ulna and placed in a groove sawn or chiselled out. The surgical method is attributed to *Brittain*, but does not include the reinforcement suggested by him of 2 extra adjacent grafts (Fig. 1). In the authors' series, only 1 bone graft is used, which corresponds to the method described by *Ely* (Fig. 2).

Bone graft arthrodesis to the distal carpal row of bones was carried out in 8 cases and to the proximal carpal row in 2 cases: 3 of these had grafts from the tibia, 2 from the iliac crest, 4 from the radius and 1 from the ulna. In 2 cases the operation was combined with wedge osteo-

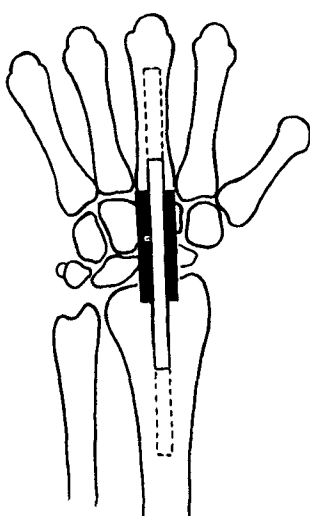


Fig. 1.

Operation according to Brittain:

Tibia graft from the radius to metacarpal III reinforced by a further two grafts.

(Brittain 1942).

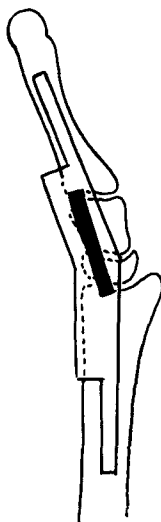


Fig. 2.

Operation according to Ely:

Tibia graft from the radius to metacarpal III.

(According to Ely 1920).

TABLE 1

Adapted surgical procedures:	
Graft transplant – radius to metacarpal III	26
Graft transplant – radius to carpus	10
Cartilage resection only – radio-carpally and intercarpally	4
Wedge osteotomy only – radio-carpally	2
42	

tomy in the radio-carpal joint and drilling and resection of the cartilage, and in 7 cases with only cartilage resection. Arthrodesis without bone graft by means of articular cartilage alone, radiocarpally and intercarpally was performed in 4 cases. Wedge osteotomy only was employed in 2 cases (Table 1). The operations were performed under general narcosis, 35, or plexus anaesthesia, 7, and in a bloodless field apart from 8 cases.

TABLE
Case

Record no. sex	Age at op. yrs.	Hand op.	Surgical procedure	Obs. period yrs.	Re-
					Radiological
<i>Polio-pareses</i>					
424/38 ♀	28	left	full cartilage resection	18	Consolidated only between radius and lunate
2957/46 ♀	31	right	wedge osteotomy radio-carp. cartilage resec. intercarp., tibia graft radio-carp. fixed by screw	12	Consolidated
4841/50 ♀	13	left	Ulna graft from radius to metacarp. III + cartilage resect.	10 6/12	Consolidated
3121/51 ♀	25	left	Tibia graft from radius to metacarp. III + cartilage resec. proxim.	7	Consolidated
3366/41 ♂	42	left	Radius graft radio-carpally + cart. resec.	18	Consolidated only between radius, navicular and lunate
808/44 ♂	32	right	Tibia graft from radius to metacarp. III	15	Consolidated
3832/48 ♂	19	left	Tibia graft from radius to metacarp. III + wedge osteotomy radio-carp.	10/12	Consolidated
6366/48 ♂	32	left	Ulna graft radio-carp. ulnar resection wedge osteotomy radio-carp. + cart. resection intercarp. + cart. destruction distally owing to drilling	11 6/12	Consolidated only between radius, lunate and triquetrum
<i>Post-traumatic pareses</i>					
48/40 ♀	17	left	Tibia graft radio-carpally, + ulna resection + cart. resection radio-carpally and intercarpally	11	Consolidated
3317/42 ♂	25	right	Radius graft from radius to navicul. + full cart. resection	1 6/12	Consolidated only between radius, navicul. and lunate

2

history.

sults		Work before/after op.	Remarks
Clinical	Subjective		
Unstable	No improvement	Housework / ditto	
Stable	No remarks	Telephonist / ditto	Post-operative fistula with spontaneous healing
Stable	No remarks	Student / Telephonist	
Stable	Considerable improvement	Nurse / Office worker (owing to other pareses)	
Unstable	No remarks	Assistant Supervisor / ditto	
Stable	No remarks	Confectioner / ditto	
Stable	No remarks	Student / Dentist mechanic	Not examined
Unstable	Hand clenching improved	Electrician / Telephonist	
Stable	Considerable improvement Occasionally slight pain with strenuous work	Sales assistant / ditto	
Unstable	When working pain without bandage	Construction worker / Precision mechanic	Not examined

TABLE

Record no. sex	Age at op. yrs.	Hand op.	Surgical procedure	Obs. period yrs.	Re-
					Radiological
1496/49 ♂	53	right	Tibia graft from radius to metacarp. III. Reoper. after 1 week owing to fracture of base of metacarp. III, graft fixed by cerclage	11	Graft fracture on level with radio-carpal joint, otherwise consolidated
<i>Spastic Pareses (C.P.)</i>					
2869/41 ♂	16	right	Tibia graft from radius to metacarp. III + wedge osteot. radio-carpally	11	Consolidated
3369/41 ♂	9	left	Cartilage resection radio-carpally and intercarpally	11	Consolidated
<i>Rheumatic polyarthritis</i>					
1013/44 ♀	27	right	Tibia graft from radius to metacarp. III + wedge osteot. radio-carpally	6	X-ray pictures are lacking
4062/44 ♀	30	left	Tibia graft from radius to metacarp. III	13	Consolidated
1585/45 ♀	12	left	Cartilage resection radio-carpally	11	Consolidated
3531/53 ♀	15	left	Tibia graft from radius to metacarpal III + cart. resection radio-carpally	6	Consolidated
	18	right	Iliac crest graft from radius to metac. III + cartilage resection radio-carpally	3	Consolidated
6158/42 ♂	52	left	Iliac crest graft from radius to metacarp. III	8	Not consolidated with metacarp. III
695/55 ♂	51	left	Iliac crest graft from radius to metacarp. III	1 9/12	Consolidated
6375/56 ♂	36	right	Wedge osteot. radio-carpally	4	Consolidated
663/57 ♂	48	right	Iliac crest radio-carpally, cart. resection, chips	3	Consolidated

2 (cont.)

Results		Work before/after op.	Remarks
Clinical	Subjective		
Unstable	Pain	Engineer / ditto	Tibia fracture following taking of graft
Stable	No remarks	Student / Office worker	
Stable	No remarks	Student / Office worker	
Stable	No remarks	Invalid owing to polyarthritis in other joints	
Stable	No remarks	Housekeeping / ditto	
Stable	No remarks	Invalid owing to polyarthritis in other joints	
Stable	No remarks	Office worker / Housekeeping	
Stable	No remarks		
Unstable distally	No remarks	Civil servant / ditto	
Stable	No remarks	Odd job man / ditto	
Stable	No remarks	Foundry worker / ditto	
Stable	No remarks	agricultural worker / ditto	

TABLE

Record no. sex	Age at op. yrs.	Hand op.	Surgical procedure	Obs. period yrs.	Re-
					Radiological
<i>Radius fracture</i>					
18059 ♀	56	left	Tibia graft from radius to metacarp. III Reop. after 14 mths. with bone chips owing to bone resorption distally	2	Not consolidated with metacarp. III
850/38 ♂	47	left	Radius graft from radius to navicular + cart. resection prox.	1	Consolidated between radius, navicular and lunate
2333/38 ♂	30	right	Radius graft radio-carpally cart. resection radio-carp. and intercarpally	21	Consolidated
6010/42 ♂	26	right	Tibia graft from radius to metacarp. III, full cart. resection	10 6/12	Consolidated
37/49 ♂	44	left	Iliac crest graft from radius to metacarp. III Reop. after 4 mths. with tibia graft owing to graft fracture	1	Graft fracture on level with joint between lunate and capitatum
<i>Navicular fracture</i>					
538/42 ♂	50	left	Tibia graft from radius to metacarpal III	6/12	Consolidated
4139/60 ♂	52	right	Iliac crest graft from radius to metacarpal III	8/12	Consolidated
3153/46 ♂	21	left	Iliac crest graft from radius to metacarpal III, cart. resection radio-carp. + intercarpal.	5/12	Consolidated
<i>Luxatio carpi</i>					
2701/37 ♂	49	left	Cartilage resec. radio-carpally + intercarpally	23	Consolidated
3746/38 ♂	46	right	Iliac graft radio-carpally	1 9/12	Consolidated only radio-carpally, not between prox. and dist. carpal row.
<i>Laceration injury</i>					
2080/44 ♂	26	right	Tibia graft from radius to metacarp. III, wedge osteot. radio-carp.	4/12	Consolidated

2 (cont.)

sults		Work before/after op.	Remarks
Clinical	Subjective		
Stable	Pain, constant aching	Packing worker / Disability pension	Causalgia since the primary trauma
Unstable	Pain	Unskilled labourer / Porter	Not examined
Stable	No remarks	Painter / ditto	
Stable	No remarks	Plater / Driver	
Unstable	Pain	Metal worker / Not started to work	
Stable	No remarks	Waiter / ditto	Not examined
Stable	No remarks	Plater / ditto	
Stable	No remarks	Churnmaker / ?	Not examined
Stable	No remarks	Odd job man / ditto	
Unstable	Pain, cannot do without bandage	Farm worker / Machine operator	
Stable	No remarks	? / ? (refugee)	Not examined

TABLE

Record no. sex	Age at op. yrs.	Hand op.	Surgical procedure	Obs. period yrs.	Re-
					Radiological
2917/48 ♂	30	left	Tibia graft from radius to metacarp. III, ulna resec., cartilage resec., radio-carpally	12	Consolidated
5862/48 ♂	26	right	Tibia graft from radius to metacarpal III, wedge osteot. radio-carpally	11	Consolidated
3202/49 ♂	31	right	Wedge osteot. intercarpally, ulnar resection	11	Consolidated
<i>Lunatomalacia</i>					
774/49 ♂	49	right	Tibia graft radiocarpally, cart. resection	12	Consolidated
4485/49 ♂	27	right	Ulna graft from radius to metacarpal III	10/12	Not consolidated with metacarp. III
1109/50 ♂	56	right	Iliac graft from radius to metacarp. III, cartil. resection radio-carpally and intercarpally	6	Consolidated
4466/55 ♂	47	right	Tibia graft from radius to metacarpal III, cartil. destruction using chisel. Reop. with bone chips after 6 mths. owing to graft fract. dist.	3	Not consolidated distally with metacarp. III
4651/56 ♂	58	right	Iliac graft from radius to metacarpal III	11/12	Graft fract. on level with carpo-metacarpal joint, otherwise consolidated
1010/60 ♂	50	right	Iliac graft from radius to metacarpal III. Reop. after 11 mths. owing to graft fract. in radio-carpal joint, with chips and osteosynthesis	1 3/12	Not consolidated in carpo-metacarpal joint, probably graft fract. here also

2 (cont.)

Results		Work before/after op.	Remarks
Clinical	Subjective		
Stable	No remarks	Unskilled labourer / Painter	Adhesions around the extensor tendons in the op. region. Tenolysis 2 mths. after operation
Stable	No remarks. Hand without function owing to pareses	Farm worker / Factory worker	Injury complicated by ulnar and median nerve lesion
Stable	No remarks	Student / Preacher	
Stable. A part from some movement in carpo-metacarpal joint with slight pain	No remarks	Carpenter/ Cleaning	Luxation trauma with navicular and styloid process fracture
Unstable	Pain	Carpenter / ?	Not examined
Stable. Adhesions around extensor tendons in the op. region	Reduced power of finger extension. Manages all his work No remarks	Builder / Office worker	Post-op. infection in the wound with graft slipping, re-op. after 2 weeks
Unstable	No remarks	Brush maker / Packer	
Rather unstable in the carpo-metacarpal joint	No remarks	Lumberjack / ditto	
Unstable	No remarks uses elastic bandage as support	Unskilled labourer / Painter	

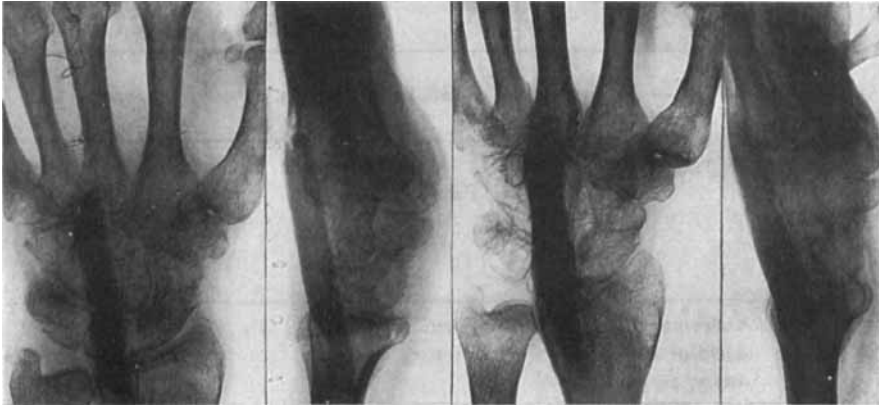


Fig. 3.

Arthrodesis with tibia graft and very short insertion into the base of metacarpal III. Left: Immediately after op. Right: after 15 years. Confectioner (808/44) fully at work without trouble. Operated on at 32 years of age owing to polio-paresis with drop hand.

RESULTS

Out of 42 arthrodeses performed on 41 patients 29 (69.0 per cent) were subjectively completely free from trouble, 4 (9.5 per cent) were much improved and 9 (21.4 per cent) stated that they had considerable residual trouble (Table 2). Amongst the 33 patients subjectively free from pain or much improved there were 12 who had performed heavy work before illness or trauma. 5 of these returned to heavy work, all with arthrodeses from the radius to the metacarpal III (Fig. 3). 2 patients out of the remaining 7 changed to lighter work owing to other injuries and the 5 others did so presumably owing to causes not concerned with the arthrodesis. No patient with radiocarpal arthrodesis only returned to heavy work such as lumberjacking or road work.

A comparison between the subjective attitude of the patients and clinical stability showed that out of the 33 who were subjectively free from pain or improved, 27 cases became stable while 8 out of the 9 cases with residual trouble were unstable.

Finger mobility and pro- and supination mobility were not made worse by any arthrodesis except in one case, where adhesions around the extending tendons of the fingers occurred through infection (1109/50).

In 2 of the laceration injuries ulna resection of 2 cms. was performed

distally and while the one remained unchanged the other improved from 45° active + 20° passive pronation and 0° supination to 80° pronation and 90° supination postoperatively actively and passively. No ulna resection was performed in the 9 polyarthritis cases. 3 maintained as before complete pro- and supination, 4 had reduced pro- and supination both before and after operation. Owing to incomplete information 2 of the cases could not be evaluated.

Actual strength measured by dynamometer was always lower on the operated side, bearing in mind left- and right handedness. Apart from the paresis cases 5 patients showed a muscle atrophy of the lower and upper arm of 1 to 2 cms. on the operated side. The actual strength of all these considerably worse on the operated side.

The average fixation period in plaster for those cases free from complication varied from 2½ mths. for the peripheral nerve injuries, 3½ mths. for the polyarthritides and 4 mths. for the post-traumatic cases to 5½ mths. for the lunatomalacias. The time for the resumption of work with or without supporting bandage varied considerably from an average of 4½ mths. for the polyarthritis cases and 8½ mths. for the post-traumatic cases to 10½ mths. for the lunatomalacias.

In 11 of the post-traumatic cases the decision of the insurance companies concerning the degree of invalidity was taken by reference to the result of the follow-up. Patients with stable arthrodeses who could return to their previous work received 20 per cent, while those who had changed to lighter work and were trouble-free without support obtained up to 33⅓ per cent. A higher percentage only occurred in cases with complicated injuries which reduced the use of the hand.

DISCUSSION

Method of Operation.

As regards the incidence of radiologically consolidated arthrodeses, no distinct difference could be demonstrated between the methods of operation utilized in the series (Table 3).

As far as subjective trouble is concerned, bone graft arthrodeses which also included the carpo-metacarpal joint seemed to produce better results than other procedures.

One would expect that the combination of bone graft arthrodesis with cartilage resection and/or wedge osteotomy would effect a more stable consolidation. This is, in fact what the series indicates. 18 out of 23 arthrodeses with the combined operation consolidated as against 10

out of 19 operated without the combined procedure. Omitting the poly-arthritis cases which have a considerable tendency towards spontaneous ankylosis and the 2 post-traumatic cases, which were already almost completely stiff, the following distribution is found:

13 out of 17 cases with combined operations consolidated,

5 out of 13 without the combined operation consolidated.

In this section of the series the difference becomes more obvious.

TABLE 3

The statistical comparison between surgical methods based on radiological signs of the consolidation of the arthrodesis show no significant difference.

	Graft Radio- meta- carp. III	Graft radio- carpally	Cartilage resec- tion only	Wedge osteot- omy only	
X-ray consolidated	17	6	3	2	28
Not fully X-ray consolidated	8	4	1	0	13
	25*	10	4	2	41*

Butler considered radio-metacarpal arthrodesis to be superior to radiocarpal, since the latter produced residual pain more often. *Merle d'Aubigné & Lafaste* found arthrodeses between the radius and the proximal carpal row to be inadequate in scaphoideus injuries and recommended arthrodeses from the radius to the distal carpal row or the metacarpus.

Abbott and his colleagues, on the other hand, declare that preservation of mobility carpo-metacarpally is important for a flexible grip and state that all 48 radiocarpally operated on consolidated and were trouble-free.

Robinson & Kayfetz carried out resection of the proximal carpal row and then fixed the capitatum to the radius by means of screws. All 12 cases, all traumatic arthritides healed without incident. Several were able to do heavy work. Precise finger work was impeded, however.

Graft Material.

In the graft fractures no distinct difference in incidence arose amongst the various transplants. 2 out of 18 tibia grafts fractured and 3 out of 11 from the iliac crest fractured. Out of 4 radius and 3 ulna grafts none fractured. The fractured grafts all extended from the

* One rheumatic case, 1013/44, is missing due to no X-rays.

radius to metacarpal III. The risk of fracture seems to be greater for grafts which pass the carpo-metacarpal joint than for the shorter grafts which only reach the carpal bones. Inadequate fixation of the carpo-metacarpal joint was probably the cause of the graft fractures. The effectiveness of the plaster fixation in the individual cases could not be judged owing to incomplete information about the plaster technique. Our series does not permit the recommendation of any definite bone graft transplant. The tibia graft has the disadvantage of longer post-operative immobilization owing to the defect in the tibia but has the advantage probably of greater firmness. One of the 18 patients operated on with tibia graft had a tibia fracture. It is an open question whether iliac crest grafts produce more rapid consolidation. It has been found in experimental research that cancellous bone (autologous, living) brings about a more powerful stimulation of osteogenesis in the host bone and swifter revascularization than cortical bone (*Woodruff*, 1960 and others). *Brittain* observed 2 fractures in 22 radio-metacarpal grafts, both iliac crest grafts. Tibia grafts were therefore recommended, reinforced by a further graft on each side (Fig. 1). All these consolidated.

Etiology.

Patients with much arthrosis or a destructive arthritic process could be expected to have a more certain tendency towards consolidation and this is shown by the series. 18 out of the 42 operated cases had considerable arthrosis and 15 of these consolidated. Only 10 out of 20 patients without arthrosis gained complete consolidation. All poly-arthritis cases healed without incident except one case (6158/42), which had an unstable carpometacarpal joint but remained trouble-free.

Age.

The average age on operation for the consolidated arthroses was 30 years as against 42 for the partially consolidated and the average age of the series, 34.6 years, with variation from 9 to 58 years. Within these limits age does not seem to constitute any contra-indication. *Colonna, Campbell and Lange* (1951) advise against the operation until X-rays have shown closure of the epiphysis, in order to avoid growth disturbances. Our 3 cases, a graft operation on a 13 year old (4841/50) and cartilage resection on a 9 year old (3369/41, Fig. 4) and a 12 year old (1585/45) did not result in any growth disturbances.



Fig. 4.

Arthrodesis following only cartilage resection radio-carpally and intercarpally at 9 years of age owing to spastic paresis with volar contracture of the wrist joint. Left: Immediately after operation. Right: after 11 years. The patient has gained much advantage functionally and cosmetically. He works in an office and has no trouble (3369/41).

SUMMARY

In this study 42 wrist joint arthrodeses are presented with an average observation period of 7.5 years. 29 (69 per cent) of these became completely free of trouble. 4 (9.5 per cent) improved considerably and 9 (21.4 per cent) declared that they had much residual trouble.

Graft arthrodeses combined with cartilage resection and/or wedge osteotomy showed a higher incidence of healing than non-combined interventions. In the graft fractures we found no distinct difference between iliac crest, tibia, ulna or radius grafts.

Graft arthrodesis from radius to metacarpal III according to *Ely* seemed in our series to produce better results than other methods.

RESUME

Dans ce travail, il est présenté 42 arthrodèses du poignet avec une période moyenne d'observation de 7 ans et demi. Parmi ces cas, 29 (69 pour cent) étaient libérés de toute gêne. Chez 4 (9,5 pour cent), l'état était sensiblement amélioré et chez 9 (21,4 pour cent), il continuait à y avoir des inconvénients graves.

Les arthrodèses-ponts combinées à une résection cartilagineuse et/ou une ostéotomie cunéiforme ont montré une fréquence de guérison plus élevée que les interventions non combinées. En ce qui concerne les fractures du pont, nous n'avons pas trouvé de différence certaine entre les ponts de crête iliaque, de tibia, de cubitus ou de radius.

Dans nos observations, l'arthrodèse-pont du radius au métacarpien III d'après *Ely* semble donner de meilleurs résultats que les autres méthodes.

ZUSAMMENFASSUNG

In dieser Arbeit stellt man 42 Handgelenksarthrodesen mit einer durchschnittlichen Beobachtungszeit von 7,5 Jahren vor. Von diesen waren 29 (69,0 Prozent) vollkommen beschwerdefrei, bedeutend gebessert 4 (9,5 Prozent) und 9 (21,4 Prozent) gaben starke fortdauernde Beschwerden an.

Spahnarthrodesen, die mit Knorpelresektion und-oder Keilosteotomie verbunden waren zeigten eine höhere Heilungshäufigkeit auf als nicht kombinierte Eingriffe. Hinsichtlich Spahnbrüchen fanden wir keinen sicheren Unterschied zwischen Crista iliaca-, Tibia-, Ulna- oder Radius-spähnen.

Die Spahnarthrodese vom Radius bis zum Metacarpale III nach *Ely* schien in unserem Material bessere Resultate zu geben als die übrigen angewandten Methoden.

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