Intramedullary Fixation with Headless Screws versus Bouquet in Unstable Metacarpal Neck Fractures in Active Patients: A Randomized Study

Fixação intramedular com parafusos de compressão versus técnica do buquê em fraturas instáveis do colo do metacarpo em pacientes ativos: Ensaio clínico randomizado

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Abstract

Objeticve To compare the range of motion (ROM), return-to-work time, visual analogue score (VAS), disability of the arm, shoulder, and hand (QuickDASH), and radiographic outcomes of two methods of definitive internal fixation in active patients with boxer's fractures, operated in the first week.

Methods This was a prospective, randomized trial, in which 50 patients, with a mean age range of 18 to 40 years old, were randomized and treated to definitive intramedullary fixation using 2 headless screws ($n = 20$) or bouquet (2 or 3 Kirschner wires) ($n = 20$). The patients were assessed on return-to-work time, ROM, patient reported QuickDASH outcome, VAS, and radiographic evaluation at 6 months.

Keywords
- metacarpal bones
- boxer's fracture
- fracture fixation, intramedullary
- minimally invasive surgical procedures
- clinical trials, randomized

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Results At 6 months, there were no differences between the two groups in terms of ROM, postoperative pain (VAS), or QuickDASH score. The overall complication rate was 4.76% in the screw group, compared with 5% in the bouquet-fixation group.

Conclusions In the treatment of the active patients with unstable boxer's fractures, headless screws and bouquet fixation proved to be a safe and reliable treatment. The outcomes were similar in both groups.

Resumo

Objetivo Comparar a amplitude de movimento (ADM), o tempo de retorno de trabalho, a pontuação na escala visual analógica (EVA), o escore no questionário abreviado incapacidade do braço, ombro e mão (QuickDASH) e os resultados radiográficos de dois métodos de fixação interna definitiva em pacientes ativos com fraturas do boxeador, operados na primeira semana.

Métodos Este foi um ensaio prospectivo randomizado, no qual 50 pacientes, com idade mediana na faixa de 18 a 40 anos, foram randomizados e tratados com fixação intramedular definitiva utilizando 2 parafusos sem cabeça ($n = 20$) ou buquê (2 ou 3 fios de Kirschner) ($n = 20$). Os pacientes foram avaliados em relação ao tempo de retorno ao trabalho, à ADM, ao desfecho relatado pelo paciente no questionário QuickDASH, à EVA e à avaliação radiográfica aos 6 meses.

Resultados Aos 6 meses, não houve diferenças entre os 2 grupos em termos de ADM, dor pós-operatória (EVA) ou escore no QuickDASH. A taxa global de complicações foi de 4,76% no grupo de fixação com parafusos, em comparação com 5% no grupo de fixação com a técnica do buquê.

Conclusões Parafusos sem cabeça e fixação com buquês provaram ser tratamentos seguros e confiáveis para pacientes ativos com fraturas instáveis. Os resultados foram semelhantes nos dois grupos.

Palavras-chave

- ossos metacarpais
- fratura de boxer
- fixação intramedular de fraturas
- procedimentos cirúrgicos minimamente invasivos
- ensaios clínicos randomizados

Introduction

Despite the high prevalence (20% of the hand fractures) of unstable neck metacarpals fractures (boxer's fractures), there is still no consensus concerning the preferred method and ideal moment of treatment, especially in active patients[1,2] for whom the time or type of management can have a strong psychological impact on the outcomes.[3,4]

The use of the intramedullary technique (headless screws or bouquet technique fixation) as the definitive treatment of unstable boxer's fractures in active patients in the first week may be a good choice of treatment. This technique is a fast, safe, minimally invasive, and easily performed reproducible method, without addressing the extensor tendon to prevent tendon adhesion and joint stiffness, enabling earlier functional recovery and shortening the return-to-work time of these patients. Choose a reproducible and effective method, which presents a cost / benefit compatible with our reality.[5–7]

The goal of the present study is to compare the return-to-work time, visual analogue scale (VAS) score, disability of the arm, shoulder, and hand (QuickDASH) score, complications rate, and radiographic outcomes of two methods of definitive internal fixation in active patients with boxer's fractures, operated in the first week.

Methods

A double center, parallel group, prospective, randomized clinical trial was conducted at the department of hand surgery of our institution. Two implants were used for fixation in closed reduction of boxer's fractures (►**Fig. 1**): the headless

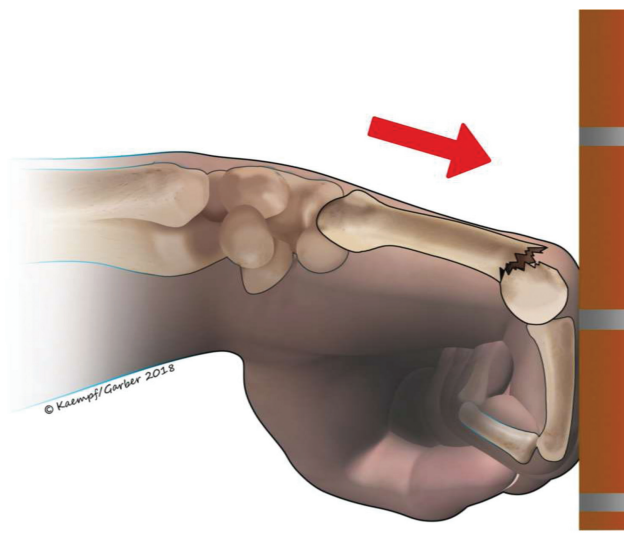

Fig. 1 Boxer's fracture mechanism and anatomic features—schematic drawing.

cannulated screws (Synthes, Davos) and Kirschner wires (k-wires)(bouquet technique) (Synthes, Davos). The protocol was approved by the local research ethics committee (CAAE 127.59813.4.0000.0082). All patients received, signed, and are aware of what was recommended in the informed consent (IC). The inclusion criteria were: presence of an acute (0–7 days), closed, and simple fracture of the metacarpal neck; absence of an ipsilateral injury or deformity; presence of an angulation of over 40 degrees in oblique plane imaging; being adults or $\geq$ 18 years old; having acquired a master's degree or being a student; and being an employee in a social-professional environment with mild physical activities.

Rotational deformity was clinically assessed based on the extension of the axis of the finger toward the scaphoid tubercle during flexion and orientation of the nail of the finger during extension. Angulation of the fracture was evaluated by measuring the angulation in the continuity of the dorsal cortical line of the metacarpal in a 30° oblique X-ray image.

The trial was registered at Clinical Trials. gov No. 32925713.9.0000.0082.

Sample Size Calculation

Patients that received an intervention based on the diagnosis of boxer's fracture between 2016 and 2017 were included in the present study after their consents were obtained. For good results, 70 degrees (standard deviation [SD]: 5) of angulation, as reported in this study, was accepted as the radiological threshold. Accordingly, the power of the study was 80%, with an α value of 0.05, and each group was comprised of 12 subjects.[8]

We Got a Similar Sample

During the study period, January 2016 to December 2017, a total of 45 patients met the inclusion criteria and did not have any of the exclusion criteria (►**Fig. 2**; Consolidated Standards of Reporting Trial [CONSORT] flowchart).[9] Five eligible patients were operated on by orthopedic surgeons

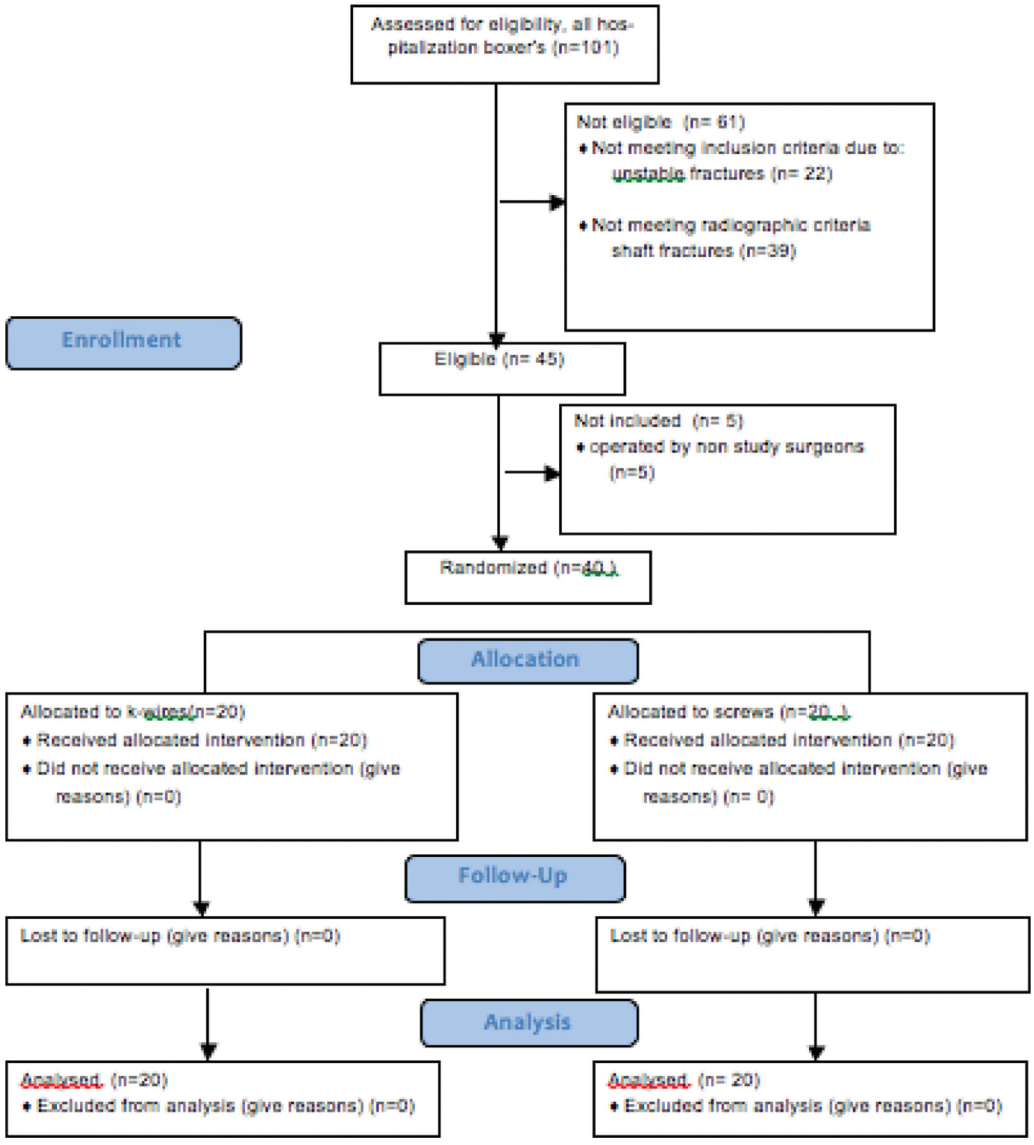

Fig. 2 Consolidated Standards of Reporting Trial (CONSORT) flowchart.

Table 1 Clinical Aspects – A Group

ID	Age	Follow-up	Side	Final ROM %	QuickDASH	Pain VAS	Return to work (days)	Complications	Other surgery
1	25	19	R	100	11.36	1	90	Y	Y
2	23	25	R	100	0	0	60	N	N
3	32	21	L	100	0	0	10	N	N
4	21	17	R	100	2.27	1	30	N	N
5	35	8	R	100	0	0	15	N	N
6	54	13	R	100	4.54	2	30	N	N
7	25	19	L	100	0	0	60	N	N
8	27	25	L	100	0	0	15	N	N
9	28	17	R	100	0	0	30	N	N
10	35	11	R	100	0	0	20	N	N
11	21	16	R	100	2.27	0	20	N	N
12	36	19	R	100	0	0	15	N	N
13	26	7	L	100	2.27	0	30	N	N
14	30	13	R	100	0	0	30	N	N
15	51	8	L	75	0	0	5	N	N
16	27	11	R	100	0	0	20	N	N
17	42	9	L	100	0	1	60	N	N
18	34	13	R	100	0	0	45	N	N
19	21	10	R	100	2.27	0	15	N	N
20	31	11	R	100	0	0	30	N	N

Abbreviations: ID, identification; N, no; Y, yes.

not participating in the study and were not included. Forty eligible patients and 41 fingers were operated in the 1st week. A posthoc analysis showed that the 40 patients included in the study did not differ regarding age, gender, or fracture type compared with the 5 not randomized but eligible patients. Of these, 4 were women and 36 men, with an average of 30.46 years (range 16–54 years).

The patients were randomized by drawing lots (heads = A - treatment with k-wires; tails = B - treatment with headless screws), which were printed and placed in 50 sealed envelopes before the study started. Randomization was blinded to all examiners. Simple randomization was used, and the envelopes were opened in the operating theater, immediately prior to the surgery. Surgical instruments for both procedures were available in a single box. Twenty patients were randomized to each group (►**Tables 1** and **2**).

The groups were similar. Thus, that patients were available for the intention to treat analysis at the 6 months follow-up (minimum) (►**Figs. 3** and **4**) (►**Figs. 5** and **6**)

Surgical Technique Description

In all patients, surgery was performed with the use of general anesthesia. The surgical method of treatment used was closed fracture reduction (the mechanism used was longitudinal traction associated with a Jahss maneuver) and stabilization.

Group A (control): All the patients were operated with an antegrade k-wire stabilization technique. A small incision was performed proximal to the base of the metacarpal; following subcutaneous dissection, a hole was made through the ulnar or radial cortex of the metacarpal, directed distally to open the canal, avoiding perforation of the contralateral cortex; one or two 1.2- mm k-wires were bent at one end to control the direction of introduction. The fracture was then reduced and the k-wires are introduced longitudinally, from the metacarpal base up to the metacarpal head. Hardware positioning was controlled intra operatively with an image intensifier (►**Figs. 3** and **4**).

Group B (tested): A 0.5 cm incision was performed at the level of the metacarpal head, and the extensor tendon was not approached, only avoided and separated, longitudinally to a similar extent. Two 1.0-mm guide wires were inserted along the longitudinal axis of the metacarpal bone under fluoroscopic guidance. The k-wires were over drilled and replaced with either two 2.4 or 3.0-mm cannulated headless compression

Table 2 Clinical Aspects – B Group

ID	Age	Follow-up	Side	Final ROM %	QuickDASH	Pain VAS	Return to work (days)	Complications	Other surgery
1	36	15	L	100	4.54	1	82	N	N
2	28	12	R	100	0	0	13	N	N
3	52	12	R	100	0	1	37	N	N
4	41	11	R	100	2.27	0	43	N	N
5	18	11	R	100	0	0	11	N	N
6	28	11	R	100	2.27	1	71	N	N
7	28	11	R	100	4.54	1	64	N	N
8	27	10	R	100	0	1	44	N	N
9	16	9	R	100	0	0	14	N	N
10	42	8	L	100	0	1	28	N	N
11	38	8	R	100	0	0	11	N	N
12	24	7	R	100	0	1	37	N	N
13	34	6	L	100	2.27	0	51	N	N
14	29	6	R	100	0	0	48	N	N
15	19	6	L	100	0		37	N	N
16	21	6	R	75	15.9	3	54	Y	N
17	29	6	L	100	0	0	10	N	N
18	29	6	R	100	0	0	7	N	N
19	41	6	R	100	0	0	6	N	N
20	23	6	R	100	0	0	13	N	N
21	22	6	R	100	0	0	9	N	N

Abbreviations: ID, Identification; N, No; QuickDASH, abbreviated form of the disabilities of the arm, shoulder, and hand; Y, Yes.

screws, based on preoperative templating. The first screw was inserted until all of the distal screw threads surpassed the fracture site, and after the second screw was placed, also surpassing the fracture site. After hardware positioning was controlled with an image intensifier (►**Figs. 5** and **6**).

All patients were radiographically and clinically assessed at 1, 2, and 8 weeks, and at 6 months. Total joint (metacarpophalangeal + proximal interphalangeal + distal interphalangeal) ROM was evaluated using a standard goniometer. The patient-reported outcome was recorded using the QuickDASH questionnaire (range, 0–100, with 0 as best result),[10,11] VAS (range, 0–10, with 0 as best result) for pain and return-to-work time.

Complications were treated and assessed at 6 months. In addition, shortening, rotation and angulation values were measured on the 30th day follow-up for both groups. Data are presented as mean or median according to type of data and distribution.

Statistical Methods

The Microsoft Excel spreadsheet in its version of MS-Office 2013 (Microsoft Corp., Redmond, WA, USA) for the organization of the data, and the statistical package IBM SPSS Statistics for Windows, Version 24.0 (IBM Corp., Armonk, NY, USA) for obtaining the results. In the statistical analyses, the level of significance of 5% (0.050) was adopted. The Fisher exact test was used to verify possible differences between both groups in terms of categorical variables.

The Mann-Whitney test was used to verify possible differences between both groups in terms of scalar variables.

Results

Categorical variables regarding side, complications, and other surgeries are found in ►**Table 3**. Scalar variables regarding age, ROM, quickDASH, VAS, and return-to-work time are found in ►**Table 4**.

There are complications: a patient (A group) showed impingement because of the k-wires, and they were removed after 3 months. A patient (B group) showed loss of reduction and he did not undergo another surgery.

Discussion

The treatment of isolated metacarpal fractures with k-wire pinning has a long and proven track record. This treatment is

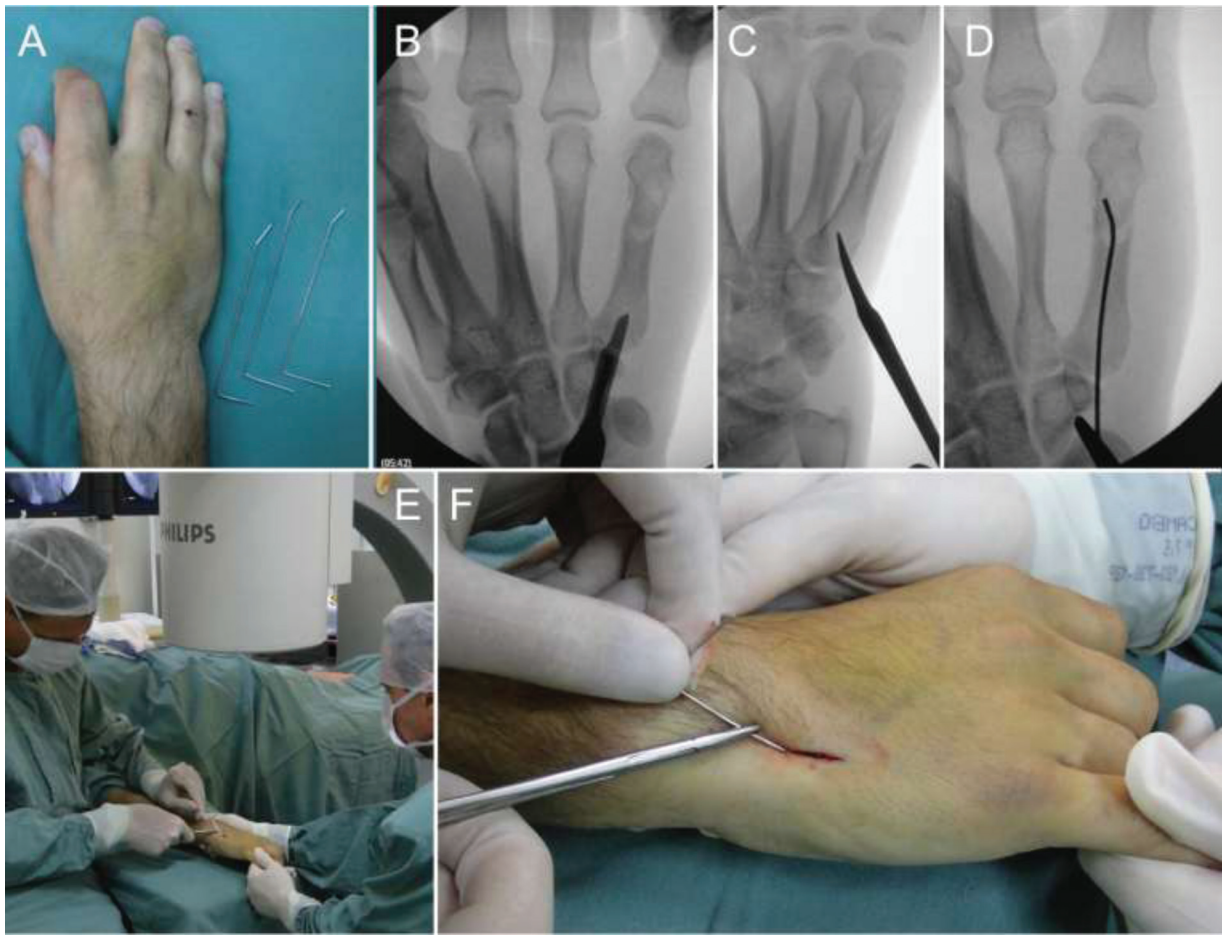

Fig. 3 Kirschner wire (K-wire) antegrade intramedullary "bouquet" fixation technique. (A) Implants and clinical view of operated limb (B) Radioscopic confirmation K-wires entry point (C) Entry point confection (D) Intramedullary K-wire advancement through fracture site. (E) Patient, surgical team, and radioscope positioning (F) Instrumentation of K-wire through subcutaneous entry point. Traction is being applied.

based on the concept of flexible fixation introduced by Foucher,[7] who described the results of the antegrade pinning technique; on their series of 66 patients with 68 fractures, all of their patients returned to their previous activities; 6 patients had a 10° extension lag; and 6 other patients had a 15° extension lag; however, only one patient, an auto mechanic, complained of this decrease in ROM. Intramedullary fixation with headless cannulated screws follows the principles of rigid stable fixation; it allows for early mobilization and decreases the need for postoperative casting. Boulton et al.[12] described the use of the intramedullary headless compression screw technique for the fixation of a fifth metacarpal comminuted neck fracture. The patient's metacarpophalangeal joint flexion at the latest follow-up was 80°; her extension was full.

Our trial included only unstable, simple, or complex fractures of the metacarpal neck (Boxer's fractures), and we had a control group with similar fractures treated with antegrade k-wire pinning versus tested group and patients treated with headless cannulated screws. Del Pinal et al.[6] and Couceiro et al.[13] showed retrospective studies, case series, and patients with shaft metacarpal and proximal phalanx fractures were included in these studies. In the present study, there were no differences between the two in terms of ROM, postoperative pain (VAS), or QuickDASH score.

A criticism of traditional conservative treatment is the inability to use cast immobilization to maintain reduction of the lateral inclination of the metacarpal bone. Ruchelsman et al.[14] and the present study demonstrated that only 2.43% of the patients showed loss of initial reduction. The current study is a prospective, randomized clinical trial, and all patients were operated by two surgeons, upper limb trauma specialists, in a uniform group, and with complete follow-up. There are limitations of the study, the sample size was small for QuickDASH and VAS analysis, but sufficient for statistical analysis for the evaluation of the ROM.

We did not find differences in terms of the mean return-to-work time or time back to their regular activities between the groups. We found no differences in terms of function or patient-related outcomes between the two techniques. We have been unable to conclude that there were any benefits in the application of one particular technique when compared

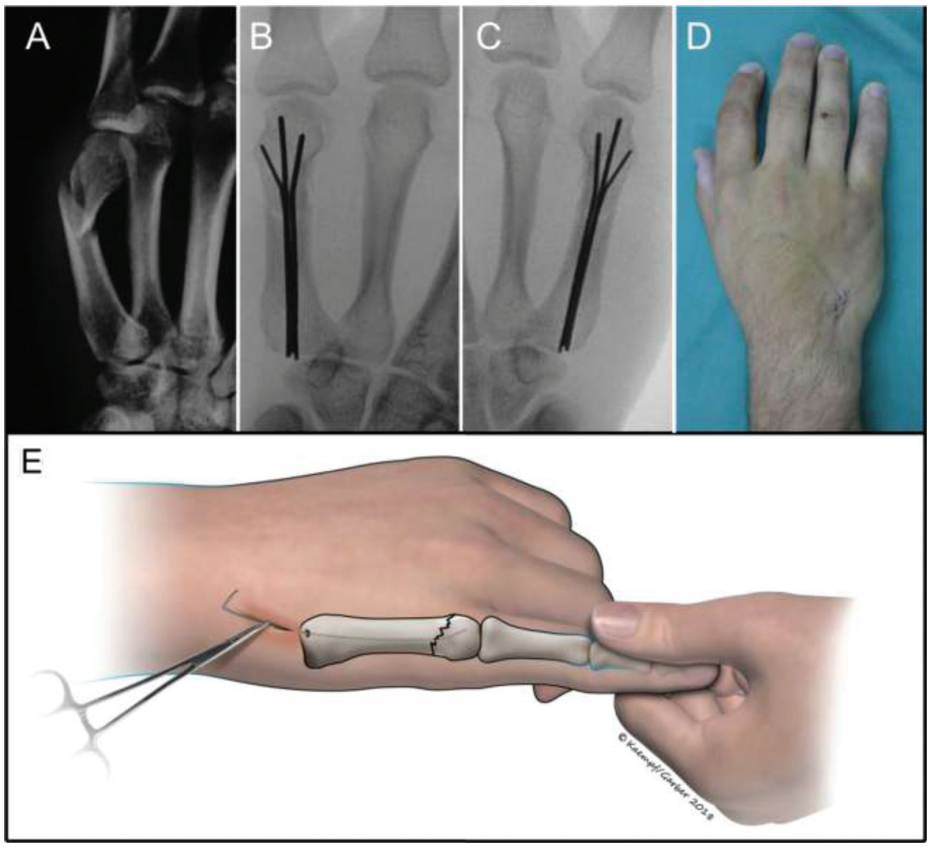

Fig. 4 Kirschner wire antegrade intramedullary "bouquet" fixation technique and radioscopic final images. (A) Boxer's fracture radiographic features. (B and C) Final radioscopic aspect—intramedullary bouquet (D) Final post operatory clinical aspect. (E) Schematic drawing—intramedullary bouquet technique.

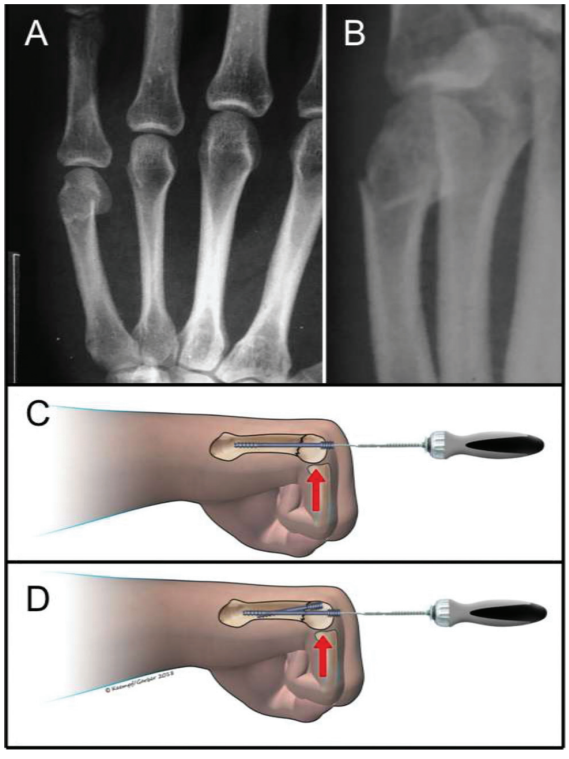

Fig. 5 Percutaneous headless screws intramedullary fixation technique. (A) Radiographic features—Boxer's fracture (B) Radioscopic features—Boxer's fracture (C and D) Headless screws retrograde intramedullary insertion.

with the other. The use of cannulated screws must be carefully weighed by the surgeon. The potential downsides include higher implant costs, the production of an injury to the articular cartilage, and the retention of metallic hardware.[13]

There is a strong trend toward the use of headless cannulated screws in the treatment of boxer's fractures; although the results found were similar, new comparative studies are needed for electing the best method.

Conclusion

In the treatment of active patients with unstable boxer's fractures, headless screws and bouquet fixation proved to be a safe and reliable treatment. The outcomes were similar in both groups, with satisfactory postoperative ROM, Quick-DASH score, VAS results, and with quick return to daily living activities.

Radiographic consolidation was observed in all of the cases.

Note

Work developed at the Department of Hand Surgery, Hospital Universitário da Faculdade de Medicina do ABC, Santo André, SP, Brazil and Hospital Mãe de Deus, Porto Alegre, RS, Brazil.

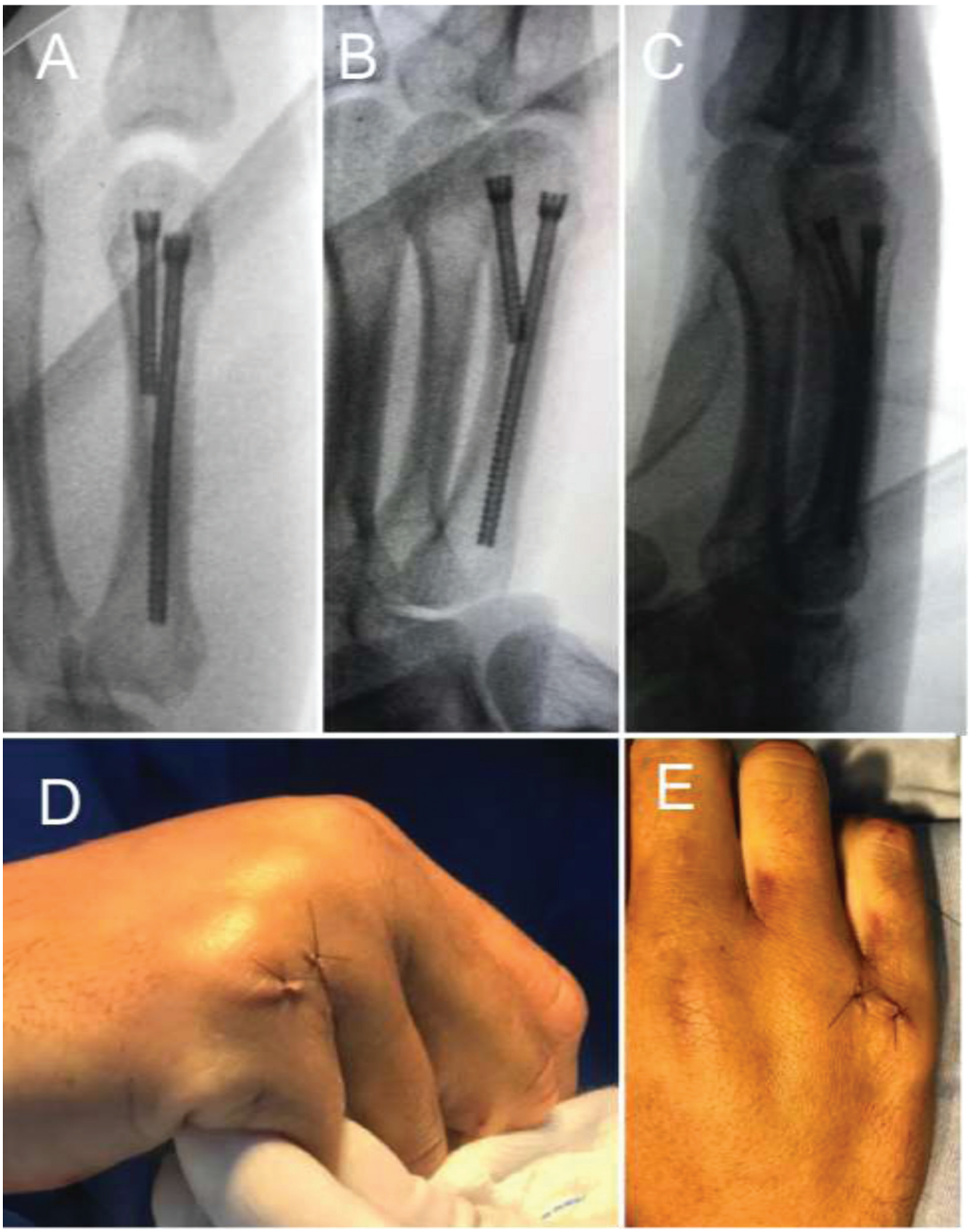

Fig. 6 Percutaneous headless screws intramedullary fixation final clinical and radioscopic images. (A–C) Radioscopic final aspect—headless screws fixation technique. (D and E) Postoperative clinical aspect.

Table 3 Categorical variables

		GROUP				Sig. (p)
		A (K-wire)		B (screw)		
		Freq.	Perc.	Freq.	Perc.	
Side	L R	6 14	30% 70%	5 16	23.8% 76.2%	0.655
Complications	Y N	1 19	5% 95%	1 21	4.76% 95.25%	0.627
Other surgery	Y N	1 19	5% 95%	0 21	0% 100%	0.300

Abbreviations: Freq., frequency; Perc., percentile; Sig., significance.

Table 4 Scalar variables regarding age, range of motion, QuickDASH, visual analog scale, and return to work (days)

Variable	Group	n	Man	Standard deviation	Min	Max	Perc. 25	Perc. 50 (median)	Perc. 75	Sig. (p)
Age (years)	A B Total	20 21 41	31.20 29.76 30.46	9.23 9.22 9.14	21 16 16	54 52 54	25 22.5 23.5	29 28 28	35 37 35.5	0.715
Follow-up (months)	A B Total	20 21 41	14.6 8.52 11.49	5.49 2.77 5.25	7 6 6	25 15 25	10.25 6 7	13 08 11	19 11 14	< 0.001
ROM (% opposite side)	A B Total	20 21 41	98.75 98.81 98.78	5.59 5.46 5.45	75 75 75	100 100 100	100 100 100	100 100 100	100 100 100	0.972
Quick DASH	A B Total	20 21 41	1.25 1.51 1.38	2.71 3.62 3.17	0 0 0	11.36 15.9 15.9	0 0 0	0 0 0	2.27 2.27 2.27	1
VAS	A B Total	20 21 41	0.25 0.52 0.39	0.55 0.75 0.67	0 0 0	2 3 3	0 0 0	0 0 0	0 1 1	0.14
Return to work (days)	A B Total	20 21 41	31.5 32.86 32.20	21.41 23.16 22.05	5 6 5	90 82 90	15 11 13.5	30 37 30	41.25 49.5 46.5	0.865

Abbreviations: Min., minimum; Max., maximum; Perc., percentile; QuickDASH, abbreviated form of the disabilities of the arm, shoulder, and hand; ROM, range of motion; Sig., significance.

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Conflict of Interests
The authors have no conflict of interests to declare.

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