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HANDSURGERY

Fifth metacarpal neck fractures treated with soft wrap/buddy taping compared to reduction and casting: results of a prospective, multicenter, randomized trial

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Abstract
Introduction The majority of fifth metacarpal neck fractures (boxers fracture) are treated conservatively without surgery. The purpose of this prospective, randomized, multicenter trial was to determine if the outcomes of soft wrap and buddy taping (SW) was noninferior to reduction and cast (RC) in boxer's fracture with palmar angulation $\leq 70°$ and no rotational deformity.
Materials and methods Sixty-eight patients with similar characteristics were prospectively enrolled and randomized at four institutions. Our primary outcome was measured by the shortened Disabilities of the Arm, Shoulder and Hand (*quick*DASH) questionnaire at 4 months. Noninferiority was claimed if there was no more than +10 points difference in the *quick*DASH. Other secondary radiographic and clinical outcomes were measured.
Results At 4 months, mean difference in the *quick*DASH between the two groups was −10.4 (95 % confidence interval, −27.0; +6.2) which was under the pre-specified margin. There was no significant difference between both groups' secondary outcomes of pain, satisfaction with the esthetic appearance, mobility of the metacarpophalangeal-joint at flexion and extension, or power grip. Increased fracture angulation, as measured on follow-up radiographs, was not significantly different between both groups. The degree of palmar fracture angulation was not related to work leave or profession. Duration of time off from work was 11 days shorter in SW compared to RC ($P = 0.03$).
Conclusion This study supports the use of soft wrap and buddy taping for treatment of boxer's fracture with palmar angulation $\leq 70°$ and no rotational deformity. Although there was no statistical difference in satisfaction with the esthetic appearance, the patient must be willing to accept the loss of the "knuckle" with this treatment method.

Keywords 5th metacarpal neck fracture · Boxer's fracture · Treatment · Cast · Soft dressing · Prospective · Randomized

Introduction

Fifth metacarpal (MC) neck fractures (Boxer's fracture) are one of the most common fractures of the hand, accounting for approximately 20 % of all hand fractures [1]. These fractures occur mostly in a working-age population and have profound socioeconomic consequences secondary to lost time at work [2].

The ideal treatment for fractures of the neck of the 5th MC remains controversial [2, 3], with the majority of patients treated without surgery [2]. Nonoperative methods include cast immobilization, with or without reduction, or functional treatment with tape [4, 5], bracing [6], or splinting [7, 8]. Surgical methods include open or closed reduction with various means of stabilization.

In 2005, a Cochrane evidence-based systematic review compared nonoperative treatment methods and concluded all available studies were underpowered and of limited quality. The authors concluded it was impossible to

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propose one optimal nonoperative treatment regimen as superior to the others [2]. Review of current literature demonstrates no consensus regarding the necessity to reduce these fractures, nor the maximum acceptable amount of fracture angulation [3].

Proponents of closed reduction and casting believe a more anatomic alignment improves outcomes. However, fracture reduction and cast immobilization requires the need for both clinical and radiographic follow-up [9]. Cast immobilization may also incapacitate an individual to work depending on their given occupations (i.e., professions in the healthcare field) [10].

The major disadvantage in nonoperative management of these fractures is the loss to follow-up due to poor patient compliance [11]. Conversely, other authors have suggested that with good education, patients do not need any follow-up [12, 13].

The purpose of this study is to compare two methods of nonoperative treatment of 5th metacarpal neck fractures [closed reduction/cast immobilization (RC) vs soft wrap and buddy tapping of 4th and 5th metacarpal (SW)] with respect to shortened Disabilities of the Arm, Shoulder and Hand (*quick*DASH) scores, pain, esthetics, work leave, MCP motion, grip strength, and fracture consolidation and angulation on radiographs.

Methods

A multicenter, prospective, randomized study was conducted in four different hospitals in Switzerland and the United States between July 9, 2010 and August 21, 2013.

The study was approved by the ethical committee/Institutional Review Board of the four participating centers and all patients underwent an informed consent prior to entering the trial.

Participants

Eligibility criteria included skeletally mature patients with an acute (<7 days) isolated fracture of the 5th MC neck who were willing to participate in the study. Radiographic requirements were angulation ≤70°, as defined on a 45° pronated-oblique X-ray on a step sponge [14], without any rotational deficit. Exclusion criteria were open fracture, rotational deformity, concomitant fractures of the ipsilateral extremity, concomitant tendon injuries, recurrent fracture of the 5th MC neck, or a history of metabolic bone disease. Patients unable to make an informed consent were also excluded. In total 68 patients (65 men) were included with a mean age of 29 years (SD ± 12 years). 35 patients (51 %) had a manual occupation, 15 a nonmanual occupation and 18 patients were without any occupation. The dominant hand was affected in 54 cases (79 %), the non-dominant hand in 14 cases.

Interventions

Soft wrap and buddy taping (SW) group (Fig. 1)

This treatment consisted of no reduction with early mobilization. The soft wrap reminds the patient of his fracture and the buddy taping prevents painful abduction of the small finger. For this treatment a circular self-adherent wrap (Coban™, 3M, Saint Paul, Minnesota, USA) was applied covering the 2nd through 5th metacarpals. The wrist and palmar aspect of the MCP joints remained free of the wrap. The small finger was buddy taped to the ring finger using Velcro™ straps (Velcro, Barcelona, Spain) [4, 5]. Patients were encouraged to move the wrist and the fingers immediately and instructed to keep the bandage on for 3 weeks. Patients were taught how to re-apply the bandage.

Reduction and cast (RC) group (Fig. 1)

This treatment consisted of reduction of the fracture and a MCP-extension cast to maintain reduction [8, 15]. The MCP-extension cast was chosen since it is easy to apply and has been previously demonstrated to maintain reduction [8].

Reduction was performed using a hematoma block of 5 ml of 1 % lidocaine. Longitudinal traction was applied for 10 min on the small and ring fingers via finger traps, followed by a closed reduction maneuver according to Jahss [16]. A 3-point molded cast was applied about the 5th MC neck fracture. This cast extended to the proximal interphalangeal (PIP) joint and immobilized the MCP joint in extension [15].

After reduction and cast placement an anteroposterior (AP) and 45° pronated-oblique radiographs were obtained to assess the adequacy of the initial reduction. Residual angulation >45° necessitated a repeat manipulation. Persistence of the residual angulation, after three attempts of reduction, was accepted as long as the angulation was ≤70°. Angulation >70° resulted in patient exclusion. The cast was removed at 4 weeks if early callus formation was demonstrated on the radiographs, otherwise immobilization was continued until the appearance of callus formation.

Outcome measurements

The primary outcome was based on a subjective measurement using the shortened Disabilities of the Arm, Shoulder and Hand (*quick*DASH) [17] questionnaire score at 4 months from the intervention.

Fig. 1 Illustration of the two different types of immobilization

As secondary outcome parameters, we assessed pain on a visual analog scale of pain in mm (VAS) [18]. The patient was asked to determine his average pain over the course of a day and mark it on a 100 mm scale. We also assessed for satisfaction concerning esthetic result using a three level scale (fully satisfied, satisfied, dissatisfied), and the duration of absence from work. We measured the range of motion (ROM) of the metacarpal phalangeal joint in flexion, using a goniometer applied on the dorsal aspect of the MCP joint, power grip using a Jamar™ model PC 5030JIA in first and second position, and fracture progression on a 45° pronated-oblique radiograph. We also assessed radiographs for bony union, as demonstrated by callus formation, by comparing to initial radiographs to follow-up radiographs at 1 week, 4 weeks, and four months following initiation of treatment.

At the first evaluation (1 week), all patients had 45° pronated-oblique radiographs of the injured hand. Fracture angulation was measured by means of the subcapital-axis angle (SCAA) [19]. The VAS was obtained and a *quick*-DASH questionnaire was filled in. Acetaminophen up to 1 g, four times per day, was prescribed to be taken as necessary. Active MCP flexion/extension of the 5th digit and power grip was measured on the contralateral side. *Quick*DASH and pain were evaluated at every follow-up. Metacarpal phalangeal range of motion and grip force was assessed only at the 1- and 4-month follow-ups.

Randomization

Patients were randomized to the SW or the RC group using a cross-off list. According to the SCCA angle [19] patients were distributed into three stratifications: (a) angulation $\leq 45°$; (b) angulation $>45°$ and $\leq 60°$; and (c) angulation $>60°$ and $\leq 70°$.

Blinding

Blinding was not possible with respect to the treatments; however, for all radiograph measurements obtained in which the patient was out of plaster, the researchers were blinded. The researchers were also blinded to all previous radiographic measurements and to which group the patient was enrolled.

Sample size and statistical analysis

The minimal detectable difference for the DASH score reported in the literature varies between 10.3 and 15 [20, 21]. For this study we established that a maximum difference of 10 points in the *quick*DASH was the maximum tolerated difference to judge treatment by SW as noninferior to treatment by RC. Using +10 points as the noninferiority margin, an alpha error of 5 % (one-sided), a beta error of 10 % and a standard deviation (SD) of the mean difference of 9.9 [21], the required sample size was 42 patients (21 patients per group). On the basis of previous studies, we anticipated 15 % attrition, so we planned to include a total of 50 patients (25 patients per group). With this sample size, we had an 80 % power to detect a 0.8 standardized difference between the two groups for the fracture angle.

All continuous variables were defined by their mean ± standard deviation (SD), median and minimum–maximum values. All categorical variables were defined by their number and relative proportions.

A Mann–Whitney nonparametric test was used to compare continuous variables between the two randomization groups. Chi-square or Fischer exact tests, depending on application criteria, were used to compare categorical variables between the two randomization groups. For

comparisons of intra-group variables (paired data), we used a Wilcoxon signed rank test.

We performed a linear regression model for each intervention group assessing the difference in the *quick*-DASH between baseline and 4 months of follow-up. There was a higher proportion of drop-out in the RC group, so we performed multivariate analysis with adjustment for the main confounders: VAS at baseline, patient age, fracture angulation and profession.

We performed a linear regression model for each intervention group, adjusting for profession and duration of time off of work, assessing the difference in the fracture angle between baseline (or post-reduction data for the RC group) and 4 months.

Statistical significance was defined as $P < 0.05$. All analyses were performed using Stata intercooled 13.0 (STATA Corp., College Station, TX, USA).

Results

Sixty-eight patients were randomized in both treatment groups (Fig. 2) with no significant differences concerning age, fracture angle or gender distribution (Table 1). More patients were included in the SW group (37 vs. 27 patients) due to a higher proportion of patients in the RC group who refused participation after randomization. Four patients dropped out of the RC group right after randomization, resulting in 64 patients total.

We did not find any statistical differences between the two group's *quick*DASH at 4 months or the difference in the *quick*DASH between baseline and 4 months (Tables 2, 3). There were no statistical differences regarding pain, satisfaction with the esthetic appearance, the ROM of the 5th MCP joint (Table 2) or power grip. After adjustment for main confounders, the difference between both groups

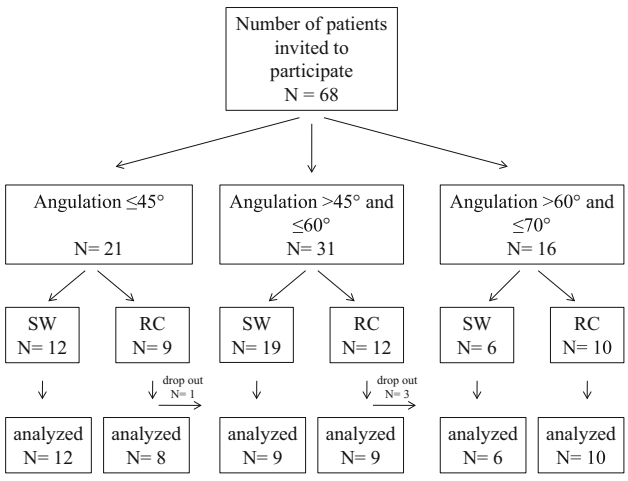

Fig. 2 Study flowchart

in the *quick*DASH between baseline and 4 months was −10.4 [95 % confidence interval (95 % CI): −27.0; +6.2] (Table 3), proving the noninferiority of SW compared to RC with an upper bound of 95 % CI below the pre-specified +10 points margin.

Patients randomized in the SW group had less time lost from work compared to those randomized the RC group ($P = 0.03$, Table 2). There was a trend for less time lost from work for nonmanual workers compared to manual workers with 21 days (±20.8 days) versus 28.3 days (±16.6 days), $P = 0.0764$. All radiographs demonstrated callus formation at 4-week follow-up.

The fracture angle progression after reduction was unchanged between the two groups ($P = 0.451$) and was not associated with duration of time lost from work ($P = 0.768$) or profession ($P = 0.308$) (Table 4). Comparing the initial fracture angles for both groups, there was a trend ($P = 0.08$) towards higher angulations in the RC, implying that fractures were initially more severely angulated in the RC group. In the SW group we observed no significant change in the fracture angulation until the 4-month follow-up, but there was a trend towards higher final angulations ($P = 0.0817$). In the RC group we measured significantly smaller fracture angulation after reduction compared to before reduction ($P < 0.001$), as well as compared to the group that did not undergo reduction ($P = 0.027$). In the RC group, need for early reduction (41° ± 12°) was followed by a significant ($P = 0.047$) loss of reduction at the 4-month follow-up (45° ± 9°). There was a significant difference ($P = 0.0122$) in fracture angulation in the RC group before reduction (53° ± 13°) and at the 4-month follow-up (45° ± 9°). There was no significant difference between fracture angulations comparing both groups ($P = 0.144$) at the 4-month follow-up (Table 2).

Discussion

The major proposed disadvantage in management of the treatment of boxer's fracture is the loss to follow-up due to poor patient compliance [11]. Therefore, a simple yet effective treatment that allows for a reduced number of follow-ups is preferable for treating this fracture pattern.

Our trial demonstrated the noninferiority of SW treatment compared to RC treatment among patients with a palmar fracture angulation ≤70° on 45 % pronated-oblique radiographs at 4-month follow-up, based on *quick*DASH scores. This means that the maximal difference of the *quick*DASH stayed inferior to the pre-specified margin of +10 points of the *quick*DASH for all patients. We did not show any difference in secondary outcomes as it relates to pain, grip strength or mobility of the 5th MCP joint. We

Table 1 Patient's characteristics at baseline

	Soft wrap/buddy taping ($n = 37$)	Reduction/cast ($n = 27$)	P values
Age (years), mean (±SD, median)	29.6 (±10.4, 28)	27.2 (±9.7, 23)	0.362
Male gender, *n* (%)	36♂, 1♀	26♂, 2♀	0.568*
Manual occupation	15	17	0.184
Nonmanual occupation	11	4	
No occupation	11	6	
Affected hand (%)			
Nondominant	5 (13.5)	8 (29.6)	0.114
Dominant	32 (86.5)	19 (70.4)	
Fracture angle (°), mean (±SD, median)	48 (13, 50)	53 (13, 53)	0.085
Stratification variables (fracture angle, °)			
A	12 (32.4)	8 (29.6)	0.142
B	19 (51.4)	9 (33.3)	
C	6 (16.2)	10 (37.1)	
*quick*DASH, mean (±SD, median)	45.7 (±18.0, 47.7)	49.7 (± 21.8, 50)	0.403
VAS (mm), mean (±SD, median)	31.9 (±19.9, 30)	35.2 (± 22.7, 40)	0.672
Flexion contralateral (°), mean (±SD, median)	92 (±12.1, 90)	92 (±19, 95)	0.446
Hyperextension contralateral (°), mean (±SD, median)	−7 (±9, −2)	−9 (±13, −5)	0.595
Power grip contralateral (kg), mean (±SD, median)			
Jamar in position 1	32 (±11, 35)	38 kg (±12, 36)	0.145
Jamar in position 2	42 (±19, 42)	41 (10, 41)	0.99

All tests according to Mann–Whitney, except * done by Fischer exact

SD standard deviation

also demonstrated that SW treatment was associated with a shorter duration of time lost from work suggesting good early recovery in terms of pain and MCP function.

We attribute this insignificant difference in pain, ROM, and strength to the relatively large degree of motion of the 5th carpometacarpal joint, which allows patients to tolerate a marked amount of angulation in the sagittal plane. This tolerance is reflected in several clinical studies, with acceptable palmar angulation reported from 70° [1, 7] to 75° [5] on oblique radiographs and 70° [22] on the true lateral radiographs. Flemming [23] stated that 70° of angulation was acceptable, but the radiological incidence is not reported.

Concern amongst surgeons regarding functional acceptable angulation is based upon biomechanical studies with cadaver hands, which concluded that 30° of angulation is the acceptable upper limit, otherwise ROM of the MCP joint could be diminished and weaken the small finger's initiation of grip [24]. Another study demonstrates significant decay in the efficiency of the flexor system for fracture angles greater than 30° [25]. In the light of our study and several other clinical studies [1, 5, 7, 22], the conclusions of these biomechanical studies appear to have limited clinical impact.

The literature also argues that angulation over 30° can result in significant cosmetic deformity [26]. In our study the majority of patients were not dissatisfied with the esthetic result, but this might be an inclusion bias, as patients were aware that they might be randomized in the group without reduction, and thus loss of the "knuckle".

Our outcomes demonstrate that after reduction there is significant progression of fracture angulation and loss of reduction for the patients in the RC group, resulting in persistent increased fracture angles compared to the initial reduction values. However, the angle progression after reduction was unchanged between the two treatment groups and was not associated with time lost from work or profession. The final fracture angles compared between groups did not demonstrate any significant difference due to a lack of power and the small difference found between the two groups.

The type of radiograph (oblique or lateral) affects the radiographic fracture angle of the 5th MC neck. In a cadaver study [27], oblique radiographs were proven to be reliable (repeatable), but demonstrated a lack of validity (accuracy) with increased fracture angles up to 35° compared to the lateral view [27]. In the same study reliability and validity of lateral radiographs were proven. A mean of

Table 2 Results at 4 month and comparison of both groups

	Soft wrap/buddy taping ($n = 20$)	Reduction/cast ($n = 19$)	*P* values*
*quick*DASH, mean (±SD, median)	0.96 (±2.7, 0) ($n = 19$)	2.78 (±5.1, 0)	0.480
Difference of *quick*DASH compared to the baseline, mean (±SD, median)	42.6 (±15.9, 43.2)	50.8 (±22.0, 54.5)	0.236
Satisfaction			
Fully satisfied	13 (65.0)	12 (63.2)	0.99
Satisfied	7 (35.0)	6 (31.6)	
Dissatisfied	0 (0)	1 (5.3)	
VAS (mm), mean (±SD, median)	1.7 (±5.8, 0)	4.6 (±10.7, 0)	0.289
Work leave (days), mean (±SD, median)	22 (±18, 25) ($n = 28$)	33 (±17, 37) ($n = 22$)	0.03
Flexion of the 5th MCP joint (°), mean (±SD, median)	92 (±9, 90)	94 (±8, 90)	0.586
Flexion of the 5th MCP joint (°), compared to contralateral side, mean (±SD, median)	1 (±10, 0)	1 (±19, 0)	0.434
Hyperextension of the 5th MP-joint (°), mean (±SD, median)	−5 (±11, 0)	−3 (±8, 0)	0.585
Hyperextension of the 5th MP-joint (°), compared to contralateral side, mean (±SD, median)	−4 (±13, 0)	−3 (±12, 0)	0.76
Power grip (kg), mean (±SD, median)			
Jamar in position 1	31 (±11, 32)	35 (±12, 35)	0.369
Jamar in position 2	41 (±20, 40)	39.7 (±11, 40)	0.649
Power grip (kg), compared to contralateral side, mean (±SD, median)			
Jamar in position 1	1 (±9, 2)	3 (±6, 2)	0.964
Jamar in position 2	1 (±9, 2)	1 (±5, 1)	0.480
Fracture angulation (°)	48.9 (±12)	45 (9)	0.144

* Non parametric test according to Mann–Whitney, except for comparison on satisfaction where Fischer exact test was applied

Table 3 Comparison of both groups at 4 month concerning the *quick*DASH using a regression model

	Regression coefficient (IC 95 %)	*P*
Group 2 (reference reduction and cast group)	−10.4 (−27.0; +6.2)	0.210
VAS (mm) at baseline	0.31 (−0.02; +0.64)	0.065
Patient age (years)	0.21 (−0.61; 1.03)	0.601
Fracture angulation (reference ≤45)		0.451
>45° et ≤60	−0.83 (−16.80; +15.14)	0.916
>60° et ≤70	−11.04 (−30.11; 8.03)	0.246
Profession (reference without occupation)		0.846
Nonmanual occupation	0.88 (−19.31; +21.06)	0.930
Manual occupation	−3.58 (−19.83; +12.67)	0.656

Table 4 Comparison of both groups at 4 month concerning the fracture angle using a regression model

	Regression coefficient (IC 95 %)	*P*
Group 2 (reference reduction and cast group)	3.12 (−5.32; +11.56)	0.451
Work leave (days)	0.03 (−0.20; +0.07)	0.768
Profession (reference without occupation)		0.308
Nonmanual occupation	5.99 (−8.05; +20.02)	0.386
Manual occupation	0.82 (−11.91; 13.54)	0.895

10.8° in higher readings was mentioned comparing oblique to lateral views [28]. Furthermore the physiological palmar angulation of a 5th MC was shown to be about 14–15° [28, 29]. We used 45° oblique radiographic views and we did not subtract the physiological 5th metacarpal palmar angulation, making our values are about 26–27°

(11.8° + 14–15°) overestimated. Other studies like ours based on oblique radiographs without subtraction of the physiological 5th metacarpal palmar angulation, recommend no reduction for fracture angulations up to 70–75° [1, 4, 5, 7].

We recognize the limitations of this study. First, a higher proportion of patients randomized in the RC group dropped out or refused participation, even though the study was clearly explained and they provided their consent. Patients stated their reasons for dropping out were because the cast treatment was unattractive, painful, and provided more constraints than SW. These reasons might explain the difficulties met during recruitment resulting in the imbalance between both groups.

Our study follow-up may be too short to identify whether pain ceases to be an outcome finding, however, we would expect residual pain to continue to improve after 4 months. Callus formation was identified on radiographs in all cases, and no significant differences in any radiographic outcome parameters were found, when compared to the contralateral side at final follow-up. We concluded that fracture healing and outcome parameters regarding strength and range of motion had stabilized at 4-month follow-up.

We had theorized that in general, most patients would elect to have the perceived most sophisticated treatment possible; however, in our study we observed the reverse, as patients avoided the RC group. It is unknown whether our patients evaluated in public and military hospitals represent a cross section of society, and their demands and expectations may be different.

In conclusion, we confirm the results of previous studies that favor immediate mobilization over plaster immobilization [4, 6, 7, 12, 22, 30, 31] as well as significant improvement in time lost from work for immediate mobilization [12]. We favor treatment by SW for fractures with $\leq 70°$ on the oblique-pronated radiograph with no rotation, as such a treatment does not demonstrate any significant differences concerning subjective and objective outcome parameters, and comes with shorter time lost from work and reduced indirect costs. It is important that patients understand the esthetic outcomes of SW treatment, and that the depression of the "knuckle" will be permanent, but does not present any clinical impact at 4 months. However, if maintenance of a significant reduction is desired, we agree with authors of a recently published study [32], that internal fixation should be used.

Compliance with ethical standards

All authors disclose any financial and personal relationships with other people or organizations that could inappropriately influence (bias) this work. The study was approved by the ethical committee/Institutional Review Board of the four participating centers and all patients underwent an informed consent prior to entering the trial.

Conflict of interest All authors disclose any financial and personal relationship with other people or organizations that could inappropriately influence (bias) this work.

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