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Comparison of three types of treatment modalities on the outcome of fingertip injuries

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PATIENTS AND METHODS

For this retrospective study, we identified all patients with an injury to the fingertip with tissue loss visiting the accident and emergency department of our hospital between January 2001 and December 2007 using local databases. The patients had either been treated by staff and/or residents of the Division of Traumatology of the Department of Surgery or by staff and/or residents of the Department of Plastic Surgery.

All fingertip injuries were retrospectively classified according to Allen⁵ (Figure 1), using the description in the files and the radiographs taken at the time of injury. Only Allen II, III, and IV injuries were included in this study because type I injuries are known to do well when treated conservatively.⁹ Injuries through or proximal to the distal interphalangeal (DIP) joint were also excluded. Patients with three or more fingertip injuries in one hand were also excluded because of the possible bias in the outcome analysis. The study was approved by the local medical ethics committee (registration numbers NL26382.042.09 and METc2008.319).

Data Collection

All eligible patients were invited to the hospital for follow-up investigation after obtaining their written informed consent. Demographic and treatment data were collected from medical files. The patients were categorized into three groups based on the treatment they had received: reconstruction (VY advancement, full-thickness skin graft, composite graft, cross-finger flap, homodigital volar step-advancement flap, first dorsal metacarpal artery flap, and an undefined transposition), bone shortening (shortening of the distal phalanx and primary skin closure), and conservative (silver sulfadiazine dressing, dry bandage and rinse out, and petroleum jelly-coated dressing). Grip and pinch strength, sensibility, and goniometry of all finger joints were used as objective outcome parameters, whereas for subjective assessments, cold intolerance, nail deformation, and aesthetics were scored. The strength and goni-

Figure 1. Allen classification of a fingertip injury: type I, pulp loss only; type II, pulp and partial nail loss; type III, pulp and nail loss and partial loss of the bone of the distal phalanx; and type IV, pulp and nail loss and partial loss of the distal phalanx through the germinative matrix.

ometry assessments were conducted using the Biometrics BV assessment system and Elink software (Biometrics, Almere, the Netherlands).

Strength

The power grip was recorded for all five positions of the precision dynamometer.¹¹ Pinch strengths (key pinch, three-jaw pinch, and the tip-to-tip pinch) of the injured finger were measured and compared with those of the contralateral uninjured finger. According to Mathiowetz,¹¹ we used the mean value of three measurements for analysis. The mean findings of the injured finger were expressed as a percentage of the mean values of the contralateral uninjured finger.

Sensibility

The Semmes-Weinstein monofilament test (SWF) and the moving two-point discrimination (2PD) test by using a Disk-Criminator (Dellon) were used to assess the sensibility of the injured and contralateral uninjured fingers. The choice for these tests was based on reliability and the practicality of their use.^{12,13} We investigated two functional sensibility zones on the palmar side of the finger: zone 1, the actual scar or flap area and zone 2, the area between the scar or reconstructed area and the flexion crease of the DIP joint.

The scores of the SWF test were categorized according to Weinstein¹² into five groups: normal sensibility 1.65 to 2.83, diminished superficial sensibility 3.22 to 3.61, diminished vital sensibility 3.84 to 4.31, absent vital sensibility 4.56 to 6.65, and not testable more than 6.65. The scores of the 2PD test were categorized into three groups according to Dellon et al.:¹³ normal, 1 mm to 5 mm; fair, 6 mm to 10 mm; poor, 11 mm to 15 mm.

Goniometry

Flexion and extension of the metacarpophalangeal (MCP), proximal interphalangeal (PIP), and DIP joints of the affected fingers and their controls were assessed according to the American Society for Surgery of the Hand standards using a digital goniometer.

The mean active range of motion (AROM) and passive ROM of each individual joint and total active motion (TAM) and total passive motion (TPM) of PIP and DIP joints of the injured finger were calculated and expressed as a percentage of the corresponding contralateral uninjured finger. We decided not to incorporate the goniometry results of the MCP joints in the calculation of the TAM and the TPM of the digit because good and excellent results of the TAM and TPM may be achieved even with diminished DIP range if the MCP and PIP ranges are higher than normal.¹⁴

Cold Intolerance

For scoring cold intolerance, the Cold Intolerance Severity Symptom (CISS) questionnaire was used. Minimum score is 0; maximum score is 100. The scores of the CISS questionnaire were categorized into five different groups.¹⁵ The reliability and validity of this questionnaire have been described.¹⁶ The mean (SD) CISS score of the normative study population, that is, volunteers with no medical history of upper

extremity operation or injury, was 12.9 (8.2) (range, 4–38.4). The upper limit of the 95% confidence interval was a CISS score of 29.3. Previous operation to the hand or arm was predictive of a significantly higher score.

Nail Deformities

The presence or absence of nail deformities was recorded by one assessor. Possible deformities were hook nail, splitting nail, nail hypertrophy, spike nail, or no nail.

Aesthetics

Patients were asked to score the aesthetic result of the finger on a visual analog scale from 0 to 10. The highest possible level of satisfaction was 10. The same was done by an independent plastic surgeon by looking at photographs of the treated fingers. The photographs were taken by a medical photographer in a standardized fashion.

Time Off From Work

The mean time off from work (in days) was recorded for all three groups.

Statistical Analysis

The resulting data were recorded in an SPSS 16.0 database (SPSS Inc., Chicago, IL). The tests used for the statistical analyses were a multiplicity of the one-way analysis of variance test, Fisher's least significant difference post hoc test, the Bonferroni test, and the Tukey test. The level of significance was set at a value of $p \leq 0.05$.

RESULTS

Eighty-four patients with 96 injuries matched the inclusion criteria. Of these, 53 patients (63%) with 59 injuries were willing to participate (Table 1). Of the patients, 22 (25 injuries) were included in the reconstructive group, 21 (23 injuries) in the bone-shortening group, and 10 (11 injuries) in the conservative group. The other 31 patients who did not respond or were not

willing to participate formed a comparable group concerning general characteristics and methods of treatment.

The characteristics of the injuries are shown in Table 2. Overall, the index finger was the most affected. Most of the injuries were classified as Allen III and IV; only six injuries were classified as Allen II. There were no Allen IV injuries in the conservative group. The only short-term complication was infection in 10.2% (6 of 59) of the cases.

No statistically significant differences and intragroup or intergroup variations could be extracted from the data given in Tables 1 and 2.

In the reconstructive group, the choices of treatment were VY advancement ($n = 9$), full-thickness skin graft ($n = 6$), composite graft ($n = 4$), cross-finger flap ($n = 3$), homodigital volar step-advancement flap ($n = 1$), first dorsal metacarpal artery flap ($n = 1$), and an undefined transposition ($n = 1$). In the bone-shortening group, the treatment was shortening of the distal phalanx and primary skin closure ($n = 23$). In the conservative group, the treatments were a silver sulfadiazine dressing ($n = 5$), dry bandage and rinse out ($n = 4$), and a petroleum jelly-coated dressing ($n = 2$).

Twenty-four of the injuries (40.7%) had been treated by trauma surgeons and 35 (59.3%) had been treated by plastic surgeons. Both groups of surgeons mainly performed bone shortening and primary closure. In the reconstructive group, the trauma surgeon/resident treated two fingertip injuries with a VY advancement; the other patients of this group were treated by plastic surgeons/residents. Overall, there was no difference in outcome after treatment by trauma surgeon/resident or plastic surgeon/resident.

Strength

In all five positions of the Jamar dynamometer, irrespective of hand dominance, the power grip of the injured hand was found to be comparable to that of the control hand ($p > 0.09$). We did not find differences between groups either.

Statistically significant differences were found neither between the injured finger and the control hand nor within the groups for the three-point pinch strength, tip-to-tip pinch strength, or key pinch strength.

TABLE 1. Characteristics of the Population

	Reconstructive, 42.4% (n = 25)	Bone Shortening, 39.0% (n = 23)	Conservative, 18.6% (n = 11)	Total, 100.0% (n = 59)
Age, mean (SD), y	40.1 (14.8)	46.7 (19.4)	39.7 (13.4)	42.6 (16.6)
Sex, % (n)				
Male	92.0 (23)	87.0 (20)	81.8 (9)	88.1 (52)
Female	8.0 (2)	13.0 (3)	18.2 (2)	11.9 (7)
Smoking	48.0 (12)	21.7 (5)	45.5 (5)	37.3 (22)
Relevant comorbidity, % (n)				
None	96.0 (24)	73.9 (17)	90.9 (10)	86.4 (51)
Vascular disease	—	—	—	—
Diabetes mellitus	—	17.4 (4)	9.1 (1)	8.5 (5)
Hand dominance, % (n)				
Right	72.0 (18)	100.0 (23)	81.8 (9)	84.7 (50)
Left	24.0 (6)	—	18.2 (2)	13.6 (8)
Ambidextrous	4.0 (1)	—	—	1.7 (1)
Follow-up, mean (SD), mo	54.0 (25.5)	53.1 (19.0)	52.1 (30.2)	53.3 (23.8)

TABLE 2. Characteristics of the Injuries

	Reconstructive, 42.4% (n = 25)	Bone Shortening, 39.0% (n = 23)	Conservative, 18.6% (n = 11)	Total, 100.0% (n = 59)
Injured finger				
Right	44.0 (11)	60.9 (14)	18.2 (2)	45.8 (27)
Thumb	8.0 (2)	4.3 (1)	9.1 (1)	6.8 (4)
Index finger	8.0 (2)	39.1 (9)	9.1 (1)	20.3 (12)
Middle finger	24.0 (6)	4.3 (1)	—	11.9 (7)
Ring finger	4.0 (1)	13.0 (3)	—	6.8 (4)
Small finger	—	—	—	—
Left	56.0 (14)	39.1 (9)	81.8 (9)	54.2 (32)
Thumb	8.0 (2)	4.3 (1)	27.3 (3)	10.2 (6)
Index finger	20.0 (5)	4.3 (1)	27.3 (3)	15.3 (9)
Middle finger	12.0 (3)	13.0 (3)	18.2 (2)	13.6 (8)
Ring finger	12.0 (3)	8.7 (2)	9.1 (1)	10.2 (6)
Small finger	4.0 (1)	8.7 (2)	—	5.1 (3)
Classification injury				
Allen II	16.0 (4)	—	18.2 (2)	10.2 (6)
Allen III	56.0 (14)	52.2 (12)	81.8 (9)	59.3 (35)
Allen IV	28.0 (7)	47.8 (11)	—	30.5 (18)
Direction of injury				
Transverse	44.0 (11)	52.2 (12)	54.5 (6)	49.2 (29)
Volar oblique	52.0 (13)	30.4 (7)	36.4 (4)	40.7 (24)
Dorsal oblique	4.0 (1)	17.4 (4)	9.1 (1)	10.2 (6)
Short-term complications				
None	84.0 (21)	95.7 (22)	90.9 (10)	89.8 (53)
Bleeding				
Infection	16.0 (4)	4.3 (1)	9.1 (1)	10.2 (6)
Flap necrosis	—	—	—	—
Long-term complications				
None	12.0 (3)	4.3 (1)	18.2 (2)	10.2 (6)
Nail deformity	88.0 (22)	95.7 (22)	81.8 (9)	89.8 (53)
Painful tight scar	8.0 (2)	8.7 (2)	—	6.8 (4)
Neuroma	—	—	9.1 (1)	1.7 (1)

Sensibility

The SWF for zone 2 was classified as “normal” or “diminished superficial sensibility.” The scores of the SWF test for zone 1 are shown in Table 3. For reasons of analysis, we dichotomized the scores. No significant differences were seen between the three treatments groups.

The scores of the moving 2PD test varied from 2 mm to 10 mm (no differences between groups, $p > 0.13$).

Goniometry

The reduction in mobility for the injured fingers compared with that of the uninjured finger was comparable be-

tween the groups. For all three groups combined, the mean reduction of the AROM of the DIP/IP was 22.0% (range, 0–48.6%); the mean reduction of the passive ROM was 18.1% (range, 0–45.3%); the mean reduction of the TAM was 12.3% (range, 0–26.1%); and the mean reduction of the TPM, 10.7% (range, 0–25.5%).

Cold Intolerance

Of the 59 fingers, 50 (84.7%) had cold intolerance (Table 4). Most individuals were found to have mild cold intolerance. The mean level of cold intolerance, as measured by the CISS, in the reconstructive group was 27.6 (moderate cold

TABLE 3. SWF Test for Zone 1 of the Injured Finger (Dichotomized)

Group (Score)	Reconstructive, 42.4% (n = 25)	Bone Shortening, 39.0% (n = 23)	Conservative, 18.6% (n = 11)	Total, 100.0% (n = 59)
1.65–2.83 (normal sensibility) to 3.22–3.61 (diminished superficial sensibility)	56.0 (14)	65.2 (15)	81.8 (9)	64.4 (38)
3.84–4.31 (diminished vital sensibility) to 4.56–6.65 (absent vital sensibility)	44.0 (11)	34.8 (8)	18.2 (2)	35.6 (21)
>6.65 (not testable)	—	—	—	—

TABLE 4. Results of the CISS Questionnaire

	Reconstructive, 42.4% (n = 25)	Bone Shortening, 39.0% (n = 23)	Conservative, 18.6% (n = 11)	Total, 100.0% (n = 59)
CISS score, mean (SD)	27.6 (20.5)	18.7 (16.1)	24.6 (14.7)	23.5 (18.0)
Group (score)				
No cold intolerance (0–3)	16.0 (4)	17.4 (4)	9.1 (1)	15.3 (9)
Mild (4–25)	36.0 (9)	56.5 (13)	45.5 (5)	45.8 (27)
Moderate (26–50)	28.0 (7)	21.7 (5)	36.4 (4)	27.1 (16)
Severe (51–75)	20.0 (5)	4.3 (1)	9.1 (1)	11.9 (7)
Very severe (76–100)	—	—	—	—

intolerance). The conservative group scored a mean of 24.6 ($p = 0.2$ compared with the reconstructive group), and the bone-shortening group scored a mean of 18.7 ($p = 0.09$ compared with the reconstructive group).

Nail Deformities

In almost 90% of all the cases, there was some kind of nail distortion. The most common alteration of the nail (47.5%) was the parrot beak deformity or hook nail (Table 5) (no differences between the groups).

Aesthetics

The mean aesthetic outcomes of the conservative group judged by patients and surgeons were 8.0 (range, 5.0–10) and 7.6 (range, 5.0–10), respectively. The bone-shortening group had mean scores of 6.9 (range, 0.0–10) and 6.8 (range, 4.5–10), respectively. The reconstructive group had mean scores of 7.1 (range, 0.0–10) and 7.0 (range, 4.5–9.5), respectively. Statistically significant differences were found neither between patients and surgeons nor within the groups.

Time Off From Work

In the reconstructive group, the patients were unable to work (the work they did before the accident) for a mean of 40.4 days (range, 2–110 days). In the bone-shortening group, this was 49.7 days (range, 2–110 days); and in the conservative group, 55.1 days (range, 28–90 days). No statistically significant differences were found between the groups.

DISCUSSION

The aim of this study was to analyze the long-term outcomes of three different treatments for fingertip injuries: surgical reconstruction, bone shortening, and conservative

treatment. For that, we subjected the injured finger on a broad spectrum of tests and determined several outcomes and compared these. This is, to our knowledge, never done before on this subject.

Our study revealed no differences in outcomes between the three treatment modalities, reconstruction, bone shortening, or conservative treatment. As such, there is still insufficient evidence to determine the best treatment method for composite fingertip defects. No prospective randomized clinical trials to evaluate one method versus another are available. The two retrospective comparative series mentioned earlier are limited in their scope, addressing the treatment of soft tissue loss. The multitude of case series with level IV evidence evaluating the various methods of composite tissue reconstruction are too disparate with respect to methods of evaluation, numbers of subjects, and objective and subjective criteria for analysis to allow for comparison and definitive conclusions. Much of the disparity in the literature, however, comes from variations in the injuries themselves. The existing classification systems^{5,17} are useful but complicated by the highly variable nature of the injuries with respect to orientation, tissue quality, vascularity, and patient factors such as age, hand use and occupation, smoking history, and concurrent diseases.

For assessing the finger function, the use of various function tests was considered. The most appropriate test and most practical for measuring hand and/or finger function is the Purdue pegboard test.¹⁸ However, we did not use this test because a patient can run a high score on the test without using the injured finger. To analyze the function of the hand, questionnaires have been developed. Examples of these are the Disability of Arm Shoulder Hand questionnaire, Michigan Hand outcome Questionnaire, and Patient Evaluation Measure. These questionnaires, however, were not specific enough, in our opinion, to measure the effects of a fingertip injury on function.

TABLE 5. Resulting Nail Deformities

	Reconstructive, 42.4% (n = 25)	Bone Shortening, 39.0% (n = 23)	Conservative, 18.6% (n = 11)	Total, 100.0% (n = 59)
No deformity	12.0 (3)	4.3 (1)	18.2 (2)	10.2 (6)
Hook nail	56.0 (14)	30.4 (7)	63.3 (7)	47.5 (28)
Nail hypertrophy	12.0 (3)	17.4 (4)	9.1 (1)	13.6 (8)
Spike nail	4.0 (1)	26.1 (6)	9.1 (1)	13.6 (8)
No nail	16.0 (4)	21.7 (5)	—	15.3 (9)

In previous studies, power strength has been expressed as a reduction percentage of the contralateral hand.^{19,20} However, in none of these studies was explained if the hand dominance was evenly spread over the groups. Therefore, we decided to incorporate hand dominance in the tests.

Surprisingly, there are no reports in which grip or pinch strength is used as an outcome parameter after a fingertip injury treatment. In the present study, as expected, the power grip was not significantly different among the three groups. However, it was surprising that comparable results were obtained using various types of pinch tests.

The SWF yielded comparable results for all three groups. Within each group, more than one half scored normal sensibility to diminished superficial sensibility. In the conservative group, even almost 82% scored normal sensibility to diminished superficial sensibility. The conservative group showed a mean 2PD test score of 1 mm to 5 mm (normal); the reconstructive group, 6 mm to 10 mm (fair). These findings are in concordance with other studies.^{9,20,21} Mennen and Wise²² in a series of 200 fingertip injuries treated conservatively found a high quality in size and bulk of the pulp and a good functional recovery. Mean 2PD test score of patients followed up to 3 months after healing was 2.5 mm, indicating normal sensitivity recovery. In the comparative study of Söderberg et al.,¹⁰ the 2PD value was identical in the regenerated and contralateral fingertip in more than one half of the patients after conservative treatment and in less than one third of the patients after operation. An increase in 2PD test score of 3 mm was more commonly seen after operation.

The functionally most important goniometric function of the fingertip, the AROM of the DIP joint, showed no significant difference between the three groups. In all three groups, there was some loss of AROM at the DIP joint. This is in concordance with the study of Ma et al.,²⁰ which reported on 200 patients who had been treated surgically or conservatively.

Cold intolerance after fingertip injury is a frequent problem, as in our study. Some think that cold intolerance and dysesthesia are a result of the injury itself, not of the treatment. Reconstructive studies with split-thickness skin grafts, VY advancement, or a local flap report 30% to 70% cold intolerance.^{23,24} However, conservative studies show the same rate of cold intolerance.²⁵ It remains unclear what the degree of cold intolerance is in these studies. In our study, most of the patients complained of cold intolerance independent of the treatment strategy chosen. Almost one half of the patients had a mild intolerance.

As can be expected by the injury of the nail bed in fingertip injuries, a lot of deformities of the nail were found. In almost 90% of all cases, there was some kind of nail distortion.

The rationale for treatment was mainly determined by the preference of the responsible surgeon, which is the greatest bias of this study. Apart from this, this study has some further limitations. First, it is a retrospective study. Preferably, a randomized clinical trial should be performed to reveal outcome differences after the three treatment strategies. In such a study, patients should be stratified for severity of injury according to the Allen classification. The latter was not feasible in our retrospective setting but may have influenced the outcome results. Second, it should be noted that the population is small

and that the conservative group is underrated (n = 11) compared with the other two groups (n = 25 and n = 23).

From the present study, it can be concluded that treatment outcomes in fingertip injuries do not differ significantly after reconstruction, bone shortening, or conservative treatment. Strength, sensibility, joint mobility, cold intolerance, nail deformities, aesthetics, and time off work were comparable in the three treatment groups. In an era where the enormous variety of surgical options suggests that treatment with a flap is the best, this outcome is at least surprising. The main drawback of the study was its retrospective setting, so a definite conclusion on the best treatment modality cannot be drawn, although the results seem to be in favor of conservative treatment. The only way to resolve the controversy of treatment of a fingertip injury is to perform a large, prospective, randomized controlled trial. Plans for such a study are currently made.

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DISCLOSURE

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