World J Surg
DOI 10.1007/s00268-014-2583-2

A Comparison of Complications in 400 Patients After Native Nail Versus Silicone Nail Splints for Fingernail Splinting After Injuries

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Abstract

Background The fingertip is the most commonly injured part of the hand and is an important aesthetic part of the hand.

Methods In this retrospective study we analyzed data from 700 patients operated on between 1997 and 2008 for complications after nail splinting with native nail or silicone nail. Inclusion criteria were patients living in Bern/Berner Land, complete documentation, same surgical team, standard antibiotics, acute trauma, no nail bed transplantation, and no systemic diseases. Groups were analyzed for differences in age, gender, cause and extension of trauma, bony injury and extent, infection, infectious agent, and nail deformities. Statistical analysis was done using the χ^2 test, Fisher's exact test, and Pearson correlation coefficients.

Results A total of 401 patients, with a median age of 39.5 years, were included. There were more men with injured nails. Two hundred forty native nails and 161 silicone splints were used. There were 344 compression injuries, 44 amputations, and 13 avulsion injuries. Forty-three patients had an infection, with gram-positive bacteria (*Staphylococcus aureus*) causing most infections. A total of 157 nail dystrophies were observed, split nails most often. The native nail splint group showed significantly ($p < 0.015$) fewer nail deformities than the silicone nail splint group; otherwise, there were no statistical differences. However, there were twice as many infections in the silicone nail group.

Conclusion It seems to be advantageous to use the native nail for splinting after trauma, when possible. In case of a destroyed and unusable nail plate, a nail substitute has to be used.

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Introduction

Finger nails are a complex aesthetic and functional unit of the human hand. Nails form at about 10 weeks of intrauterine life. A well-grown nail at birth indicates maturity of the fetus [1]. The nail helps to increase the sensory perception in the pulp and helps in picking up small objects [2]. They serve as armor for the distal digit and play an important role in daily life and in society. It is obvious to the observer when a nail is missing and today artists are trying to create replacements or beautifying accessories with artificial nails.

The nail unit consists of several interdependent structural components: the germinative portion (matrix and nail bed epithelium), the nail plate, the framing (nail folds and grooves), its sheathing (cuticles, eponychium, and hyponychium), and the supportive tissues (nail unit fibrocollagen). The nail plate has three distinct layers histologically: a thin dorsal layer that gives it a smooth surface, a thick intermediate layer, and a ventral layer with an irregular surface featuring longitudinal striations, allowing adherence to the nail bed [3, 4].

When a person sustains an injury to the nail bed, especially to the germinative zone, dystrophic nail growth can

Published online: 29 April 2014

result, such as a split nail, spoon nail, or onycholysis. Another factor that has to be taken into account is the extent of bone injury [5, 6]. Gross irregularities in healed bone of the distal phalanges can contribute to nail deformities such as split nails or onycholysis [5, 6]. Nail dystrophy, however, may also result from an infection of the nail bed [7]. Infections will cause destruction of the nail bed by direct involvement of bacteria or by pressure from edema [6]. Any purulence should be drained quickly by removing the bandage or the nail. To prevent nail deformity secondary to injury of the nail bed during operation, a gentle technique and microsurgical instruments are necessary.

Once a nail plate is destroyed, it is unusable for splinting a nail bed. Alternatives such as splinting devices made out of syringes, plastic, or commercially available silicone plates, can be put onto the nail bed. However, in clinical practice patients present with dystrophic nail growth despite splinting or develop infections when using native nail plates or plastic-based nails splints, resulting in dystrophic nail growth.

At our institution we have used native nails and silicone-based nail splints over 10 years. The aim of this retrospective study was to compare splinting of the nail bed using native nail plate versus the silicone nail and to evaluate both splints for complications.

Patients and methods

From 1997 to 2008 the nail bed in 700 patients was reconstructed at the Department for Hand Surgery and Surgery of the Peripheral Nerves. Inclusion criteria for this study were patients living in Bern or the Berner Land, acute trauma (compression, avulsion, or amputation or combination thereof) to the finger/thumb, and immediate treatment, including splinting with native nail plate or silicone plate. Exclusion criteria were infections, previous operations, secondary treatment for treated trauma, tumors, osteoarthritis-based changes, systemic diseases such as psoriasis, Lupus erythematosus, Raynaud's disease, iron deficiency anemia, hemochromatosis, pulmonary or cardiac problems, continuously inserted artificial nails, no splinting of the nail bed during surgery, and a follow up-period too short to evaluate for nail deformities. A total of 401 patients were finally included in the study.

Nail beds were reconstructed using 7/0 absorbable suture material. For perioperative antibiotic therapy, cefuroxime was used on a regular base. Native nail plates were preserved if possible and used as splints for the reconstructed nail beds. Before use, the native nails were macroscopically cleaned and then bathed in an iodine solution for 10 min. If the nail plate had been discarded or was simply too damaged to be used, an artificial nail splint was cut from a 10-cc syringe to match the needed shape. All nail splints were cut to the size needed, trephined before, and sutured to the perionychial wall using 4/0 nonabsorbable suture material, one or two at each side (Figs. 1, 2). Care was taken to keep the eponychial fold open by inserting the splint into it. The splints were left in place until the new nail protruded from under the eponychial fold.

Fig. 1 Silicone nail splint, sutured to the perionychial walls at each side. The splint was constructed from a 10-cc syringe

Fig. 2 Native nail splint after nail bed reconstruction. The nail was cut to the size of the nail bed and sutured to the epinychial walls

All patients had regular follow-ups in the outpatient clinic. If any signs of infection were observed, swabs of the infected tissue were taken and sent for bacteriological evaluation. The infected finger was immobilized with a splint. Immediate antibiotic treatment was started using cefuroxime and adjusted accordingly to bacteriological resistograms. If necessary, the nail splint was taken off.

Table 1 Population characteristics

Patients (*n*)	Total (401)	Group A (240)	Group B (161)	χ^2 test	Fisher's exact test
Male	340	204	124	0.5	
Female	61	36	37	0.3	
Age (mean)	3–84 (39.5)	40.2	39.5	0.6	
Follow-up (mean)	2–24 (13.2)	3–24 (13.2)	2–24 (13.2)	0.8	
Native nail	240	240			
Silicone nail	161		161		
Nail deformities	157	63	77	0.01[a]	0.015[a]
Nail deformities and infections	97	52	44	0.7	
Infections	67	43	21	0.5	
Compression	344	201	143	0.9	
Avulsion	44	30	14	0.6	
Amputation	13	9	4	0.7	
Gram positive	50	33	17	0.7	
Gram negative	17	11	6	0.8	
Heavy injury	217	129	88	0.9	
Less heavy injury	184	111	73	0.9	
2-Piece fracture nondisplaced	101	61	40	0.9	
2-Piece fracture displaced	73	42	31	0.8	
3-Piece fracture non displaced	49	29	20	0.8	
3-Piece fracture displaced	88	54	34	0.8	
More than 3-piece fracture nondisplaced	12	7	5	0.9	
More than 3-piece fracture displaced	80	49	31	0.8	
Closed reduction and splinting	114	73	41	0.5	
Closed reduction and K-wire fixation	71	42	29	0.9	
Open reduction and splinting	34	19	15	0.9	
Open reduction and K-wire fixation	182	104	76	0.8	

[a] Statistical significance $p < 0.05$

Two groups of patients were formed: those with a native nail splint (group A) and those with a silicone nail substitute splint (group B).

X-rays were taken at the time of surgery and evaluated for injury to the distal phalanx (Figs. 1, 2). Injuries were categorized into 2-piece fractures, 3-piece fractures, or more than 3-piece fractures, displaced and nondisplaced, respectively. Injuries can be classified based on anatomic location or on the nature of the injury [2]. Therefore, trauma was differentiated into heavy, when the eponychium, especially the germinative zone, was injured or parts of the nail bed were missing, and less heavy otherwise. Trauma was also sorted into crush injury, avulsion, and amputation. If the trauma was a combination of two or three types of trauma, it was categorized as the heavier type of injury. The groups were evaluated statistically for age, gender, cause and extension of trauma, bone injury and extent, infection and infectious agent, nail deformities and infection, and nail deformities dependent on or independent of infection, when using different splinting techniques.

Statistical analysis was done using the χ^2 test and Fisher's exact test, using the SPSS program (SPSS, Inc., Chicago, IL, USA). Spearman, Pearson, and Kendall correlation coefficients were calculated using the SPSS program.

Results

Combined results groups

Patient age ranged from 3 to 84 years. Median age was 39.5 years. The follow-up period after injury ranged from 2 to 24 months, and mean follow-up was 13.2 months. Men (85 %) were injured more often than women (15 %). Two hundred forty native nails and 161 silicone splints were used. There were 344 compression injuries, 44 amputations, and 13 avulsion injuries. Thirty-nine percent of all treated patients had a postoperative nail deformity and 24 % had an additional infection with nail deformity. Sixty-seven patients suffered from an infection. The nail deformity most often observed was the split nail ($n = 113$), followed by the claw nail deformity ($n = 35$). Overall, the infectious agent most often observed was the gram-positive bacterium *Staphylococcus aureus* (54 %), followed by

Table 2 Infectious agents and group analysis

	Gram positive			Gram negative	
	Staphylococcus aureus (%)	*Streptococcus epidermidis* (%)	*Pseudomonas aeruginosa* (%)	*Enterococcus faecium* (%)	*Bacteroides fragilis* (%)
Total	36 (54)	12 (18)	2 (0.5)	11 (3)	6 (1.5)
Group A	24 (10)	8 (3)	1 (0.4)	7 (3)	4 (2)
Group B	12 (7)	4 (2)	1 (0.6)	4 (2)	2 (1)
χ^2 test	0.1	0.7	0.6	0.7	0.7

Table 3 Nail deformities

	Split nail	Claw nail	Spoon nail
Total	113 (72 %)	35 (22 %)	9 (6 %)
Group A	52 (22 %)	22 (9 %)	6 (3 %)
Group B	61 (38 %)	13 (8 %)	3 (2 %)
χ^2 test	0.06	0.7	0.7

Streptococcus epidermidis (18 %). Gram-negative infectious agents caused fewer infections, only 4.5 % of the cases with infection. Two hundred seventeen injuries were heavy and 184 were less heavy. The fracture pattern most often observed was 2-piece nondisplaced (25 %) followed by 3-piece displaced (20 %). Most injuries were treated by open reduction and K-wire fixation (45 %) (Table 1).

Separate results groups

Group A had 62 male (85 %) and 11 female (15 %) participants, whereas group B consisted of 42 male (77 %) and 12 female (23 %) patients. Median age was similar in both groups (group A, 40.2 years and group B, 39.5 years). There were no statistically significant differences between the groups. Group B had significantly more nail deformities than group A, but infections were equally distributed within the groups. In group A, 43 patients (18 %) suffered from an infection, whereas in group B, 21 patients (13 %) presented with an infection after treatment. Also, gram-positive and gram-negative infections were observed in the groups at similar rate. In both groups, *S. aureus* (10 % in group A and 7 % in group B) was the gram-positive bacterium most often observed, and *Enterococcus faecium* (3 % in group A and 2 % in group B) was the gram-negative bacterium most often found (Table 2). The χ^2 test and Fisher's exact test did not show any statistically significant differences between the groups ($p < 0.4$). Similar results were seen in both groups with respect to no nail dystrophy but had infection. Both groups showed similar percentages of types of injuries. Crush injury was the most common trauma, with 84 % in group A and 89 % in group B. Similar percentages were seen for grade of injury, i.e., heavy or less heavy, as well as bone injuries (Table 1). Group B had more split nails (38 %) than group A (22 %) but the difference was not statistically significant (Table 3). There were no statistically significant differences between the two groups in age, gender, trauma and trauma extent, bone injuries, and infectious agents (Table 1).

Statistical analysis for 3-piece fractures, displaced and nondisplaced, as well as more than 3-piece fractures, displaced and nondisplaced, showed that they corresponded to nail bed deformities (Spearman correlation 0.85, Pearson 1, Kendall 0.94). A high correlation between nail deformities and infections was found (Spearman correlation = 0.77, Pearson = 0.68, Kendall = 0.78).

Discussion

Trauma is the most common cause of nail deformity, and fingertip injuries are commonly seen in the emergency department [2]. Trauma may cause scarring in various directions in the nail bed. If the scar is very narrow, nail adherence might not be affected. In our study, no nail deformities or nail growth disturbances were observed in 343 patients. This might be due to the use of a thorough closure technique using 7/0 Vicryl absorbable suture material and microinstruments. Closed trauma injuries to the nail bed happen when there is mild crush trauma to the fingertip, such as in door crush injury. This results in a subungual hematoma. If the X-ray does not show any fracture, the nail plate should be trephined and the trauma can be managed conservatively [2]. If the X-ray shows any fractures, it is better to remove the nail plate and repair the laceration with fine absorbable sutures. We used 7/0 absorbable suture material which has enabled us to provide a good repair of the nail bed. Some effects of trauma are scar formation leading to nonadherence (onycholysis), splitting, angulated growth, or absence of all portions of the nail plate. It is therefore important to repair the nail bed and secure it during nail regeneration to prevent painful

deformities and promote patient comfort during subsequent dressing changes [4]. In our study we observed 157 nail deformities in total. Most were found in the group treated with silicone nail splints.

Open trauma results in deformity that is easily diagnosed, the nail plate is frequently avulsed and the nail bed is exposed. This macrotrauma also may lead to loss of part of or the entire nail bed [2]. In our patient population, 217 patients suffered a heavy-type injury, including rupture of the germinative zone. Also, in 229 patients there were three or more bone piece fractures, displaced or nondisplaced. Statistical evaluation showed a good correlation to nail dystrophies. This is concordant with the literature [2]. However, these patients were equally distributed in both groups. In some cases, secondary reconstruction using nail bed transplantation might be necessary [2]. Patients who underwent a secondary reconstruction were excluded from our study.

Bone injuries of the distal phalanx have been described as contributing to formation of nail deformities [5, 6]. It is crucial to obtain a closed nail bed [5, 6]. We treated displaced fractures by closed reduction and splinting or by open reduction, K-wire fixation, and splinting until the bone heals. A closed nail bed was achieved in all cases, either by direct closure or by nail bed transplantation. Both groups of native and silicone nail splinting showed no statistically significant difference between open and closed reduction and K-wire fixation and splinting alone.

In a traumatically injured nail bed, it is crucial to keep the proximal nail fold open. The fold will obliterate within days if a nail substitute is not inserted, resulting in complete loss of nail growth or nail ingrowth into the fold. In the literature there are few articles on the topic of nail bed injuries and splinting. Some authors suggest the temporary use of metal foil splints or acrylic nails [8, 9]. However, foil splints can lead to staining of the nail bed, which is difficult to remove [10], and they are expensive and not easily available. Ogunro [11] reported on a new nail bed splint, the INRO surgical nail splint. Although results with it seem to be promising, the device has not been used much. Other authors reported on the use of silicone-based materials as splints, such as nasogastric tubes [12] or syringe plastic [4]. These materials are easily available and are ready to shape as nail bed splints. However, the nasogastric tube splint is not as stiff as acrylic or metal splints and may lack the needed durability to armor the distal digit against external forces, where as the metal splints might be too hard for the nail bed and lead to additional injuries. In our study, we used a silicone nail splint made from a 10-cc syringe. This material is easily available and nail splints of various sizes can be readily made. Another advantage we have seen with this splint is that the radius of the syringe comes close to that of the native nail bed. If there is a difference in size, the splint material can be adjusted by bending. Because of its stiffness it will sustain the adjusted shape. This size difference might be the reason for the higher rate of nail deformities observed, as the shape of the splint cannot be adjusted as finely as needed to shape the repaired nail bed.

Silicone splints are widely used but previous studies have shown that their success rate seems to be low [11]. At our institution we have used silicone nail bed splints or native nail plates for splinting for more than 10 years. This study demonstrated that treatment with silicone splints results in a higher rate of nail deformities compared to native nail splints. One reason might be that the silicone splint is too rigid to adjust to the shape of the nail bed, thereby not providing the flexibility needed. Native nail plates are smoother than silicone and they already have the natural shape of the repaired nail bed. This natural shield might provide the ready shaping needed for the nail bed.

Another reason for dystrophic nail growth is inflammation and invasion of microbes. Infections after surgery are serious complications and cause destruction of the nail bed by direct involvement of bacteria or by pressure from the edema of the surrounding tissue. In our study we have observed more patients with infections in group A. However, the number of patients evaluated was much higher in group A than in group B and once the infections were resolved fewer nail dystrophies were observed. This might be due to the higher rigidity of the native nail plate, which helps to shape the underlying nail bed naturally.

Infections are a well-described complication after surgery of the finger, especially in contaminated and dirty wounds [7]. The risk of infections increases from 13 % in contaminated wounds to 40 % in dirty wounds. The infectious agents most often found are *S. aureus*, *Streptococcus*, and *Pseudomonas.* This is concordant with our results. The gram-positive infectious agent most often observed was *S. aureus*, followed by *Streptococcus epidermidis*. The gram-negative agent most often observed was *E. faecium*. This bacterium causes infections in wounds contaminated with feces. This bacterium is also a typical intestinal resident in cattle [13]. Our patient population consisted mainly of people employed in agricultural work. This might be the reason why there was a high number of infections caused by *E. faecium* and crush injuries by contaminated machine parts.

Other reasons for nail deformities are consistent and repeated picking at the eponychium that detaches the dorsal roof from the nail. Nail surface deformity may result from vigorous pushing back of the eponychium or freeing of the eponychial border from the nail to insert artificial nails [1]. At our institution, care was taken to insert the nail plate or silicone nail splint gently into the eponychial fold to avoid any further damage to the nail bed.

In conclusion, we have demonstrated that native nails might be advantageous for splinting of the nail bed after trauma. If the native nail cannot be used or is destroyed, an alternative nail splint other than silicone might be needed.

Acknowledgments This study was made possible by departmental funds.

Conflict of interest None of the authors has any conflict of interest.

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