



# Comparative Analysis of a Modified Secondary Healing Protocol for Fingertip Amputations and Non-microsurgical Reconstruction Techniques\*

## *Análise comparativa de um protocolo de cicatrização secundária modificado para amputações das pontas dos dedos e técnicas de reconstrução não microcirúrgicas*

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### Abstract

**Objective** To describe and compare the results obtained with a secondary healing protocol for fingertip amputations and their relationship to injury severity according to the Allen classification.

**Methods** Medical records of 127 fingertip injuries were revised, and a retrospective, comparative, analytical study the amputations treated conservatively was performed. Injury characteristics, healing time, and complications were described and analyzed.

**Results** Between April 2017 and May 2019, 127 fingertip injuries were treated conservatively. The average age of the sample was of 28.33 years. The average healing time was of 4.31 weeks. The complications during the follow-up were observed in 18.9% ( $n=24$ ) of the cases, but none require revision treatment. A statistically significant relationship between the development of complications and treatment revision according to the Allen classification was not found ( $p \geq 0.05$ ).

**Conclusion** The proposed secondary healing protocol has shown to be safe and effective in types 1 to 3 fingertip amputations in the Allen classification, and it should be included as a therapeutic option even in injuries of greater extension than those that have traditionally been limited to.

### Keywords

- finger injuries
- amputation
- hand injuries
- wound healing

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## Resumo

**Objetivo** Descrever e comparar os resultados obtidos com um protocolo de cicatrização secundária para amputações das pontas dos dedos e sua relação com a gravidade da lesão de acordo com a classificação de Allen.

**Métodos** Foram revisados os prontuários clínicos de 127 lesões nas pontas dos dedos, e realizou-se um estudo retrospectivo, comparativo e analítico das amputações tratadas de forma conservadora. Foram descritas e analisadas as características da lesão, o tempo de cicatrização, e as complicações.

**Resultados** Entre abril de 2017 e maio de 2019, foram tratadas de forma conservadora 127 lesões nas pontas dos dedos. A idade média da amostra era de 28,33 anos. O tempo médio de cicatrização foi de 4,31 semanas. As complicações apresentadas durante o acompanhamento afetaram 18,9% ( $n = 24$ ) dos casos, porém nenhum exigiu tratamento de revisão. Não foi encontrada relação estatisticamente significativa entre o desenvolvimento das complicações e a revisão do tratamento de acordo com a classificação de Allen ( $p \geq 0,05$ ).

**Conclusão** O protocolo de cicatrização secundária proposto mostrou-se seguro e eficaz nas amputações das pontas dos dedos conforme os tipos de de 1 a 3 da classificação de Allen, e deve ser incluída como opção terapêutica mesmo em lesões de maior extensão do que aquelas tradicionalmente limitadas.

## Palavras-chave

- traumatismos dos dedos
- amputação
- traumatismos da mão
- cicatrização

## Introduction

Fingertip injuries are among the most common injuries of the hand, resulting in ~ 4.8 million annual visits to emergency services.<sup>1</sup> The wide variety of surgical techniques described can be confusing, and the clinical evolution and final results are affected by the chosen method. The needs of the patient necessity and the experience of the specialist must be taken into consideration to make a decision.<sup>2</sup> Some objective considerations in order to choose the appropriate technique are: the angle of tissue loss, bone exposure, the condition of the amputated portion, injuries to the adjacent fingers, the affected finger, and the extension of the defect. Although there is no strict treatment algorithm, the objectives should be minimization of pain, optimization of the healing time, preservation of sensitivity and function, limitation of deformities in the nail plate, reduction of the time until return to work and, if possible, fostering of cosmetic results, highlighting the preservation of the greatest possible length. Although there are different surgical techniques for the reconstruction of the defects, the conservative treatment by secondary wound healing yields favorable results.<sup>3-7</sup>

In our center there was no experience related to the conservative treatment. Fingertip amputations were previously treated with conventional surgical techniques (VY flaps or free skin graft), until conservative techniques became the standard for these injuries as part of the initial management and, most of the time, as the definitive treatment. The objective of the present study is to analyze the evolution, the final results, and the incidence of complications among patients treated by secondary healing and to compare the results

obtained through four different types of injuries according to the Allen classification.

## Methods

The present study was approved by the research and ethics committees of the institution. This is an observational, retrospective, comparative, analytical study performed in patients with traumatic fingertip amputations between April 2017 and May 2019. The amputated tips were reviewed and categorized into four types according to the Allen classification. The initial management was performed in the emergency room, following aseptic techniques and under local anesthesia. All patients included were followed up for a minimum period of six months. Patients injured by animal or human bites, and those with initial management in another institution or with incomplete follow-up, were excluded. The extent of the injuries was determined according to Allen's classification.<sup>8</sup> General characteristics of the study population and the duration of the treatment are described. Early and late complications in each treatment group are also described, and the need for revision treatment and preservation of the initial length were evaluated. The relation between these variables and the mechanism and extent of injury were analyzed.

## Statistical Analysis

The resulting information was analyzed in the Statistical Package for the Social Sciences (IBM SPSS Statistics for Windows, IBM Corp., Armonk, NY, United States) software, version 25.0. For the statistical analysis, the Chi-squared test

and the Kruskal-Wallis test were used. The level of significance was established as  $p \leq 0.05$ .

### Secondary Healing Protocol

In the emergency room, the affected finger is put under regional anesthesia with the conventional technique, with 2% simple lidocaine. The wound is irrigated with sterile saline solution and gently debrided with sterile gauze. Amputations with exposure of the distal phalanx were remodeled with gouge and rasp at the level of the edge of the pulp. Ketanserin gel (Sufrexal, Janssen-Cilag, Beerse, Belgium) was applied throughout the extent of the amputation; then, a semipermeable adhesive membrane (Tegaderm, 3M, Saint Paul, MN, United States) was applied to cover the defect. Finally, the entire finger circumference from the distal interphalangeal to the metacarpophalangeal joints was covered with sterile gauze and fixed with surgical tape (Micro-pore, 3M), and a tubular elastic net was fixed to the base of the affected finger. Every patient received prophylactic oral antibiotic and tetanus toxoid reinforcement vaccination. The patients were evaluated after 3 to 5 days in an outpatient clinic, where they underwent wound cleaning by irrigation with sterile saline solution without debridement; then, ketanserin gel was reapplied, and the wound was covered again with a new semipermeable adhesive membrane, a procedure repeated weekly until epithelialization of the defect was achieved.

### Results

Between April 2017 and May 2019, 127 fingertip injuries were treated in the emergency room by the trauma service (► **Table 1**). The average age of the patients was of 28.33 years (range: 1 to 76 years), with a predominance of male subjects (82.7%;  $n=105$ ). The most commonly affected finger was the middle finger (31.5%;  $n=40$ ), and the most common mechanism of injury was crushing (70.9%;  $n=90$ ). Most injuries were classified as Allen type 2 (42.5%;  $n=54$ ) (► **Fig. 1**). The overall average duration of treatment was 4.3 weeks, and was found to be directly proportional to injury severity

**Table 1** Characteristics of the population and results

Mean age (years)	28.33
Gender: % (n)	
Male	82.7 (105)
Female	17.3 (22)
Diabetes mellitus: % (n)	0.8 (1)
Smoking: % (n)	12.6 (12)
Mechanism of injury: % (n)	
Crushing	70.9 (90)
Cutting	29.1 (37)
Allen classification: % (n)	
Type 1	32.3 (41)
Type 2	42.5 (54)
Type 3	17.3 (22)
Type 4	7.9 (10)
Complications: % (n)	
Wound infection	0.8 (1)
Seroma	2.4 (3)
Persistent bone exposure	5.5 (7)
Painful fingertip	10.2 (13)
Fingertip necrosis	–
Pain related to nail deformity	–
Revision treatment: % (n)	6.3 (8)
Length shortening after failure: % (n)	1.6 (2)
Average healing time (weeks)	4.31

according to Allen's Classification ( $p < 0.001$ ). From the total amount of fingertips treated, 18.9% ( $n=24$ ) presented a complication, the 3 most frequent being hyperalgesia (10.2%;  $n=13$ ), persistent phalanx exposure (5.5%;  $n=7$ ), and seroma (2.4%;  $n=3$ ). Wound infection was only present in one patient, and it was resolved with the use of short-course oral antibiotics (► **Fig. 2**). These complications had a higher incidence in patients classified as Allen type 2 (45.8%;  $n=11$ ), followed by type 1 (25%;  $n=6$ ), 4 (16.6%;  $n=4$ ) and 3 (12.5%;  $n=3$ ). The amount of patients classified as Allen type 2 might explain the higher incidence of complications found when compared with those classified as Allen type 3. The Allen classification was significantly related to the development of complications ( $p \leq 0.05$ ) (► **Table 2**).

Finally, we also found a statistically significant ( $p \leq 0.0001$ ) relationship between the Allen classification and the preservation of the maximum length of the fingertip; the need to shorten the initial length to achieve closure was reported in 2 patients (1.6%) classified as Allen type 2.

### Discussion

Fingertips amputations are among the most commonly treated work accidents worldwide, although there is no consensus regarding their treatment. In developed countries,



**Fig. 1** A 68-year-old male patient with an Allen type 2 injury compromising the third and fourth fingers. (A) Acute presentation. (B) After five weeks under the secondary healing protocol.



**Fig. 2** A 49-year-old female patient with an Allen type 3 injury on the thumb. (A-C) Acute presentation. (D-F) After six weeks under the secondary healing protocol. An asymptomatic nail deformity is shown.

the management is reported to be increasingly in favor of microsurgery techniques; however, in the United States, only 15% of hospitals perform reimplantation surgeries. Less than 10 surgeries per year are reported, that is, only 14% of fingertip injuries are treated with this method, while, in Japan, 29% of the cases are treated microscopically.<sup>9</sup> Another alternative is amputation or remodeling. In the cases revised in the present study, remodeling as a primary treatment, that is, surgical shortening to achieve secondary healing, was only offered to 22.7% ( $n=45$ ) of the patients. The remaining 77.3% ( $n=155$ ) were submitted to some form of reconstructive treatment, either conservative or surgical, therefore enabling the preservation of as much length as possible, and, consequently, obtaining both a better functional and cosmetic result in those patients with no clinical restrictions. This surgical shortening is still the initial treatment in many centers, since it enables a prompt return to work. Its indications and technique show the heterogeneity observed in the management of hand injuries. In a study<sup>10</sup> conducted among 592 members of the American Society for Surgery of the Hand, 56% showed a preference for disarticulation over trans-bone amputation, and only 7% preferred to adjust the level of amputation according to the closure, in an attempt to preserve as much as possible the length of the finger. The demographics of the subjects of the present study is similar to those reported in other series<sup>7,11,12</sup> with a predominance of young men with crushing injuries, and the second and third fingers being the most commonly affected, as reported by Torres- Fuentes et al.<sup>12</sup> The diversity of studies with different treatment proposals for the management of these injuries demonstrates the variability in opinion of hand surgeons, plastic surgeons, and orthopedic surgeons. Likewise, the diversity of classifications described in recent years only complicates the unification of criteria.<sup>13,14</sup> According to

**Table 2** Different factors and their involvement in the development of any complication

	Complica- tions (n)		p-value
	Yes	No	
Diabetes mellitus (n = 1)	1	0	< 0.05
Smoking (n = 16)	2	14	> 0.05
Mechanism of injury (n = 127)			
Cutting (n = 37)	6	31	> 0.05
Crushing (n = 90)	18	72	
Allen Classification (n = 127)			
Type 1 (n = 41)	6	35	< 0.05
Type 2 (n = 54)	11	43	
Type 3 (n = 22)	3	19	
Type 4 (n = 10)	4	6	

the Allen classification, most of the injuries were type 2, a group in which the treatment with advancement flaps has traditionally been considered suitable, particularly Atasoy VY flaps; however, skin borders are frequently irregular or very damaged, and resection must be done before advancing the flap. Type-1 Allen lesions are traditionally considered as irrefutable candidates for the conservative management with secondary healing, but not types 3 and 4. In the present study, 25.3% of fingertip amputations treated by secondary healing were classified as types 3 and 4. If we consider the total of amputations treated conservatively, only 6.3% ( $n=5$ ) required additional interventions due to complications. Therefore we can assert that injuries of greater extension than Allen's 1 and 2, may be safely managed with this modality of treatment. The noteworthy benefits observed include: simplicity, low cost, reproducibility, availability of material resources, adequate attachment; it can be used safely in diabetic patients and in those with a history of smoking. In the case of pediatric or apprehensive patients, it does not require painful procedures or procedures performed in the operating room, avoiding the risks of anesthesia. On the other hand, the main disadvantage is the long duration of treatment, which results in a relatively long period of inability to return to work, this is similar to the periods reported by van den Berg et al.<sup>7</sup> Some patients were initially anxious about the smell and exudate produced within the first weeks; however, after an explanation, they were satisfied. Psychological factors have already been related to negative impacts on the functional perception after the treatment, greater pain intensity, and an increase in the period until the return to work. Therefore, the identification and treatment of symptoms of depression will contribute to facilitate the recovery.<sup>15</sup>

The protocol used for secondary healing has demonstrated effectiveness and safety in the population studied, and allowed us to demonstrate the capacity of tissue

regeneration at least in this portion of the human body, a controversial and current issue.<sup>16</sup>

It is important to declare that the decision to use ketanserin gel is based on its wide commercial availability in our country and on the experience obtained in the treatment of vascular and diabetic ulcers; however, a recent Cochrane meta-analysis<sup>17</sup> showed inconclusive results regarding its effectiveness compared to that of other substances. Since other topical agents, such as petroleum jelly and silver sulphadiazine, have also been described for the conservative management of fingertip amputations,<sup>6</sup> we believe the results shown in the present study cannot be directly related to ketanserin, but to a microenvironment rich with the proper growth factor, humidity control, and hygiene obtained through a close follow-up and early interventions, as needed.

To demonstrate the superiority of this method over the surgical approach, studies with a randomized, prospective design are necessary to objectively assess the results at the end of each treatment. Meanwhile, and given the limitation in material and human resources for the application of microsurgery techniques worldwide, any treatment option that demonstrates acceptable cosmetic results, a prompt reintegration into work activity, and good functional results should be considered an alternative by the surgeon.

## Conclusion

Secondary healing with the described protocol has demonstrated to be effective and safe in the management of Allen types 1 and 2 fingertip amputations, and satisfactory results were obtained in some cases of Allen type lesions; therefore, it should be considered as a therapeutic option even in lesions with great extensions.

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### Conflict of Interests

The authors have no conflict of interests to declare.

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