Minimally invasive surgical treatment for unstable fractures of the proximal phalanx: intramedullary screw

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Objective: To analyze the clinical-functional parameters and quality of life of patients undergoing minimally invasive surgical treatment for extra-articular fractures of the proximal phalanx, using an intramedullary screw (Acutrak®).

Methods: Between January 2011 and September 2014, a prospective study was conducted on 41 patients (48 fingers) with unstable extra-articular fractures of the proximal phalanx, who underwent minimally invasive surgical treatment using an intramedullary screw (Acutrak®). These patients were evaluated 12 months after the surgery by means of the DASH quality-of-life questionnaire, VAS pain scale, measurement of range of motion (ROM, in degrees) and radiographic assessment.

Results: All the patients achieved adequate reduction and consolidation of their fractures. There were statistically significant improvements in quality of life on the DASH scale, pain on the VAS scale and range of motion.

Conclusion: The minimally invasive technique for treating unstable extra-articular fractures of the proximal phalanx using an intramedullary screw (Acutrak®) is effective and safe, and it presents satisfactory clinical-functional results.

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Tratamento cirúrgico minimamente invasivo das fraturas instáveis da falange proximal: parafuso intramedular

Objetivo: Analisar os parâmetros clínico-funcionais e a qualidade de vida de pacientes submetidos ao tratamento cirúrgico minimamente invasivo das fraturas extra-articulares da falange proximal com uso do parafuso intramedular (Acutrak®).

Métodos: Um estudo prospectivo foi feito de janeiro de 2011 a setembro de 2014 e incluiu 41 pacientes e 48 dedos acometidos com fratura da falange proximal extra-articular e instável.
Introduction

Fractures of the phalanges are frequent injuries and account for 6% of all fractures.\(^1,2\) Fractures of the proximal phalanx occur more often than those of the middle or distal phalanges.\(^3,4\)

Indications for surgical treatment of these fractures need to take into consideration the type of fracture line, the displacement between the fragments and the difficulty in maintaining open reduction of the fracture.\(^3\) This treatment has the main aim of restoring the anatomy and function of the finger affected.\(^4,5\)

The techniques that have been described vary from provision of relative stability to the principle of absolute stability. A combination of methods is sometimes necessary,\(^5\) and this depends on the nature of the fracture line, the availability of implants and the surgeon’s preference.

Among the surgical complications, the following stand out: joint stiffness, adherences and/or tearing of the extensor tendon,\(^1\) functional loss of the finger\(^2\) or, furthermore, skewed consolidation, pseudarthrosis and osteomyelitis.\(^5-7\)

These complications are frequently caused by lack of knowledge of the biomechanics of this organ, by an unfounded belief that all fractures of the hand can be resolved through conservative treatment or by poor patient cooperation.\(^8\)

In seeking to minimize these complications, we provide here the first description of the principle of an intramedullary internal tutor,\(^9-11\) comprising use of a conical compression screw (Acutrak\(^\text{®}\)) that was inserted percutaneously. This procedure presents the advantage of not interfering with the extensor tendon, so as to avoid tendon adherence and joint stiffness.

The objective of this study was to analyze the clinical and functional results from patients with a diagnosis of unstable reducible extra-articular fracturing of the proximal phalanx with displacement, who underwent surgical treatment by means of a minimally invasive percutaneous osteosynthesis technique using an Acutrak\(^\text{®}\) screw in order to avoid interfering with the extensor tendon of this finger.

Materials and methods

Between January 2011 and September 2014, 41 patients with 48 fingers affected were attended and evaluated at the outpatient service of the hand and microsurgery group of our institution. A prospective study was conducted, which included all the patients who presented a diagnosis of unstable reducible fractures of the proximal phalanx of the fingers and who underwent physical examination and simple posteroanterior (PA) and oblique radiography on the hand and PA and lateral (L) radiography on the finger affected.

The inclusion criteria were that the patients needed to be adults aged 18–65 years, of either sex, with a clinical and imaging diagnosis of unstable reducible fractures of the proximal phalanx of the fingers, who had signed a free and informed consent statement and a protocol of conflicts of interest, as required by our institution’s research ethics committee through CAAE number 12759813.4.0000.0082.

Patients were excluded if they had any associated diseases in the hand or any osteometabolic diseases, if they had undergone any previous surgical procedure on the hand, or if they presented any chronic conditions that affected the hands bilaterally.

The functional evaluation was performed by professionals within the hospital’s occupational therapy sector for the hand. The clinical and functional measurements were made as percentages of the range-of-motion (ROM) measurements in degrees on the normal finger versus the affected finger, using a single specific goniometer. The clinical analysis on pain was done by means of a visual analog scale (VAS) from zero to 10, for a subjective evaluation.

Quality of life was evaluated by means of the DASH questionnaire (Annex 1), which is an instrument validated for assessing the upper limbs.

Radiographs of the consolidation of the fracture were evaluated subjectively by the medical team.

The patients underwent osteosynthesis of the phalangeal fracture, without interfering with the extensor tendon. All of the operations were performed by means of a percutaneous minimally invasive technique, with implantation of an Acutrak\(^\text{®}\) screw, following the intramedullary tutor principle, in order to stabilize the fracture of the proximal phalanx.

Operative technique for osteosynthesis using an Acutrak\(^\text{®}\) screw

A percutaneous approach to the base of the proximal phalanx was used, comprising a 0.5 cm incision under the lateral face of the extensor tendon in its dorsal region, with
Fig. 1 – View of the entry point of the screw at the dorsal base of the proximal phalanx, showing the preservation of the joint cartilage at the base of the proximal phalanx, in the metacarpophalangeal joint. Dissection of a cadaver.

a percutaneous minimal approach to the extensor hood affected. Closed reduction of the fracture of the proximal phalanx was then performed, with the aid of traction along the finder, while maintaining the proximal and distal interphalangeal joints. This reduction was done under indirect viewing, with the aid of radioscopy. A guidewire was then passed into the apex of the dorsal face of the phalange such that it crossed the fracture focus, going toward the distal and palmar region of the bone until it crossed this cortical bone, with preservation of the condyles. After this, the size of the implant was measured and the medullary canal was milled using a specific conical drill bit. The Acutrak® screw was then inserted into the intramedullary canal below the distal cortex, in the proximal region of the phalanx, next to the palmar cortex of this bone (Fig. 1). In this manner, compression and stabilization of the fracture focus became possible, with the aid of radioscopy, in order to maintain the screw in its ideal position. At the end of the procedure, suturing was performed in layers and postoperative radioscopy and radiography of the hand were performed for post-surgical assessment (Figs. 2 and 3).

Statistical analysis

We used Microsoft Excel electronic spreadsheets (version in Microsoft Office 2010) to organize the data and the Statistical

Central trend measurements were made (mean, minimum, maximum, standard deviation and percentiles) and these were then compared using Wilcoxon’s signed rank test (Table 1), with the aim of checking for possible differences between continuous variables, for each variable of interest.

Package for the Social Sciences (SPSS; IBM), version 22.0, to obtain the results. Values with \( p < 0.005 \) were taken to be statistically significant and a 95% confidence interval was used.
Table 1 – Epidemiological distribution and postoperative follow-up of the patients.

| Number | Age (years) | Finger affected | Follow-up (months) | Return to work | Complications |
|--------|-------------|-----------------|--------------------|----------------|---------------|
| 1      | 36          | 2nd right       | 12                 | Before 6 months | No            |
| 2      | 36          | 3rd right       | 12                 | Same occupation | No            |
| 3      | 48          | 4th right       | 12                 | Same occupation | No            |
| 4      | 26          | 2nd right       | 12                 | Other occupation| Yes           |
| 5      | 23          | 4th left        | 12                 | Other occupation| No            |
| 6      | 19          | 4th left        | 12                 | Same occupation | No            |
| 7      | 29          | 5th right       | 12                 | Same occupation | No            |
| 8      | 36          | 1st left        | 12                 | Other occupation| No            |
| 9      | 21          | 3rd right       | 12                 | Same occupation | No            |
| 10     | 24          | 2nd right       | 12                 | Other occupation| Yes           |
| 11     | 24          | 3rd right       | 12                 | Other occupation| No            |
| 12     | 36          | 4th left        | 12                 | Same occupation | No            |
| 13     | 48          | 2nd left        | 12                 | Other occupation| No            |
| 14     | 41          | 3rd right       | 12                 | Same occupation | No            |
| 15     | 21          | 5th right       | 12                 | Same occupation | Yes           |
| 16     | 30          | 2nd right       | 21                 | Same occupation | No            |
| 17     | 32          | 3rd right       | 20                 | Other occupation| No            |
| 18     | 25          | 3rd right       | 20                 | Same occupation | No            |
| 19     | 28          | 5th right       | 20                 | Same occupation | No            |
| 20     | 19          | 3rd right       | 18                 | Same occupation | No            |
| 21     | 23          | 1st right       | 18                 | Other occupation| No            |
| 22     | 25          | 2nd left        | 17                 | Same occupation | No            |
| 23     | 25          | 3rd left        | 17                 | Same occupation | No            |
| 24     | 29          | 5th left        | 17                 | Same occupation | No            |
| 25     | 32          | 5th left        | 17                 | Other occupation| No            |
| 26     | 30          | 5th left        | 17                 | Same occupation | No            |
| 27     | 25          | 2nd right       | 15                 | Same occupation | No            |
| 28     | 47          | 4th right       | 16                 | Same occupation | No            |
| 29     | 19          | 5th right       | 12                 | Same occupation | No            |
| 30     | 28          | 5th right       | 12                 | Same occupation | No            |
| 31     | 28          | 4th right       | 12                 | Same occupation | No            |
| 32     | 23          | 5th right       | 12                 | Other occupation| Yes           |
| 33     | 28          | 3rd right       | 12                 | Other occupation| No            |
| 34     | 28          | 4th right       | 12                 | Other occupation| No            |
| 35     | 28          | 5th right       | 12                 | Other occupation| No            |
| 36     | 25          | 3rd right       | 33                 | Same occupation | No            |
| 37     | 29          | 5th right       | 32                 | Same occupation | No            |
| 38     | 46          | 1st right       | 32                 | Same occupation | No            |
| 39     | 29          | 4th left        | 32                 | Same occupation | No            |
| 40     | 51          | 5th right       | 31                 | Same occupation | No            |
| 41     | 38          | 1st left        | 31                 | Same occupation | No            |
| 42     | 29          | 2nd right       | 23                 | Same occupation | No            |
| 43     | 29          | 3rd right       | 23                 | Same occupation | No            |
| 44     | 36          | 5th right       | 20                 | Same occupation | No            |
| 45     | 42          | 5th right       | 20                 | Same occupation | No            |
| 46     | 21          | 3rd left        | 19                 | Same occupation | No            |
| 47     | 36          | 5th left        | 19                 | Same occupation | No            |
| 48     | 19          | 2nd right       | 19                 | Same occupation | No            |

Source: Hospital service files.

Results

All the patients maintained the reduction that had been achieved through the operation, along with their fracture consolidation.

All of them presented improvement in their clinical and functional parameters and there were improvements in their results regarding the variables of range of motion (ROM) (Fig. 4), DASH (Disability of the Arm, Shoulder and Hand) score and visual analog scale (VAS) score (Table 2). All the patients achieved improved quality of life and returned to work, with significant decreases in their DASH questionnaire scores (Fig. 5). There was an improvement in pain, with decreases in their VAS scores (Fig. 6).

In comparing the clinical and functional results with those of the unaffected side (range of motion, DASH and VAS), we observed that there was no statistically significant difference between the values analyzed, which showed that functional recovery of the fingers affected had been achieved.

The complication rate was 8.33%. Patient 4, with abrasive injuries to his fingers, presented postoperative infection, with exposure of the implant, which was removed after consolidation of the fracture. Patients 10, 15 and 32 evolved with pain...
in the middle phalanx, perhaps because of the great length of the screw. It was removed after the fracture had consolidated, and this improved the pain. The length of follow-up was 17 months, with a minimum of 12 and maximum of 36. The mean age was 30 years, with a minimum of 19 and maximum of 51.

Discussion

Evolution in treating fractures of the proximal phalanx is a necessity in our setting, not only because of the increasing incidence of these fractures here, but also because the results from conventional osteosynthesis methods are unconvincing.\textsuperscript{7-10} The search for less invasive techniques has the aim of reaching procedures that act toward stabilizing the implant while enabling early mobilization of the finger with a low complication rate.\textsuperscript{11-14}

For this purpose, a variety of means have been developed, such as the new 1.5 or 2 mm specific locking plates with a minimum thickness of 2 or 3 mm, in association with guiding tools and reducing tweezers that are extremely precise. The Acutrac\textsuperscript{®} self-compressing screw, which was designed previously for treating scaphoid fractures and is now used for the proximal femur, the bones of the foot and ankle and even the proximal phalanges, under the intramedullary tutor principle, as described in this study, enables the proper stability that is needed for fractures of the proximal phalanx.

The percutaneous minimally invasive approach using a compression screw,\textsuperscript{14-17} under the internal tutor principle and without interfering with the extensor tendon, significantly diminishes the risk of adherence of the tendon to the implant. This can be explained by the fact that there is no contact between the extensor tendon and the implants. In this manner, there is less risk of joint stiffness in these fingers, since the method applied in this study is sufficiently stable to allow mobility of the metacarpophalangeal and interphalangeal joints as early as the immediate postoperative period. The deformities are minimal because of the ease of reducing the fracture and maintaining this over the course of the follow-up, when this method is applied.\textsuperscript{16-18}
In analyzing the radiographic parameters, all the patients maintained the fracture reduction that was initially achieved. It was demonstrated that both of the implants used in this study are safe and stable and that they enable adequate bone consolidation.

In comparing the clinical and functional results horizontally with the unaffected side (range of motion, DASH and VAS), we observed that there were no statistically significant differences, which shows that functional recovery of the affected fingers was achieved.

Our clinical and functional results (ROM) were better than those obtained in the study by Itadera et al., in which the patients were treated by means of a minimally invasive technique using intramedullary wires that did not produce anatomical reductions.

Held et al. used conservative treatment with a specific orthosis and found that 91% maintained the fracture reduction. In our study, we believe that surgical treatment was more effective, with results close to 100%, similar to other published studies.

With regard to evaluating the complications, the study by Yan et al. showed worse functional results and a higher complication rate among patients treated using conventional techniques. Among the complications, edema, pseudoarthrosis, joint stiffness and postoperative infection of the surgical site can be highlighted. This event was observed in 8.33% of the patients in our study, and it was treated through removal of the implant, serial dressings and antibiotic therapy, with improvement of the condition beyond the sixth postoperative week. According to the review study by Gaston and Chadderdon, the ideal surgical approach for unstable fractures of the proximal phalanx in athletes is minimally invasive treatment in association with implants with greater resistance, so as to enable mobility and an early return to sport. This concept was applied in the present study, which showed satisfactory results such as a DASH score of 3.56 and a complication rate of 8.33%.

A comparison between intra and extramedullary tutors was made in the study by Ozer et al., in treating diaphyseal fractures of the femur, tibia and humerus. They showed that milled nails (intramedullary tutors) in the femur and tibia were superior and presented lower complication rates. However, in relation to the humerus, conservative treatment and use of percutaneous bridging plates presented lower complication rates.

In this study, we sought to approach the diaphysis of the phalanx by means of a minimally invasive technique, in a manner similar to approaches used in relation to other bones, as described in the literature. In an analogous manner, we used a nail (the Acutrak® screw) as an intramedullary tutor, in order to treat extra-articular fractures of the proximal phalanx.

We observed that the learning curve was short. This technique was safe and it adequately maintained the initial reduction of the fracture that had been achieved surgically, with satisfactory results and a low complication rate (8.33%).

Conclusion

The minimally invasive technique for treating unstable extra-articular fractures of the proximal phalanx using the Acutrak® screw was effective and safe, and it presented a low complication rate. The implants maintained adequate reduction of the fracture.

Conflicts of interest

The authors declare no conflicts of interest.
Anexo 1. DASH questionnaire in portuguese version.

The questionnaire is about your experiences, asking how useful they are for you to answer activities. To your answer, respond to all questions based on your condition on the day of the questionnaire.

If you do not have the opportunity to perform an activity in the same way as usual, please estimate what you expect would be a worse case.

Do not impute if you do an activity in the same way as usual, please estimate what you expect would be a worse case.

If you answer, respond based on your ability independently of the way you did it.

Meia a sua habilidade em fazer as seguintes atividades na semana passada circulando a resposta apropriada abaixo:

| Atividade                                                                 | Não deixa de fazer | Pouso | Média | Muito | Extremamente |
|--------------------------------------------------------------------------|--------------------|-------|-------|-------|-------------|
| 1. Fazer um vdo novo ou com a amiga muito apertado                         | 1 2 3 4 5          |       |       |       |             |
| 2. Escrever                                                               | 1 2 3 4 5          |       |       |       |             |
| 3. Fazer uma comida                                                       | 1 2 3 4 5          |       |       |       |             |
| 4. Preparar uma refeição                                                  | 1 2 3 4 5          |       |       |       |             |
| 5. Abrir uma porta presa                                                  | 1 2 3 4 5          |       |       |       |             |
| 6. Colocar algo em uma prateleira alta da sua casa                       | 1 2 3 4 5          |       |       |       |             |
| 7. Fazer tarefas domésticas presas (por exemplo: lavar louças)            | 1 2 3 4 5          |       |       |       |             |
| 8. Fazer trabalho de jardineiro                                           | 1 2 3 4 5          |       |       |       |             |
| 9. Assegurar a casa                                                       | 1 2 3 4 5          |       |       |       |             |
| 10. Consertar uma sapatilha ou uma malha                                 | 1 2 3 4 5          |       |       |       |             |
| 11. Consertar um roupão preso (mais do que não)                          | 1 2 3 4 5          |       |       |       |             |
| 12. Fazer uma limpeza acima da cabeça                                     | 1 2 3 4 5          |       |       |       |             |
| 13. Fazer a cama ou o sofá                                                 | 1 2 3 4 5          |       |       |       |             |
| 14. Lavar suas roupas                                                     | 1 2 3 4 5          |       |       |       |             |
| 15. Vestir uma blusa presa                                                | 1 2 3 4 5          |       |       |       |             |
| 16. Usar uma faixa para ecorar alentores                                  | 1 2 3 4 5          |       |       |       |             |
| 17. Atividades recreativas que exigem peuo esforço (por exemplo: jogar cartas, etc.) | 1 2 3 4 5 |       |       |       |             |
| 18. Atividades recreativas que exigem esforço ou impacto no corpo        | 1 2 3 4 5          |       |       |       |             |
| 19. Atividades recreativas que exigem esforço ou impacto no corpo         | 1 2 3 4 5          |       |       |       |             |
| 20. Transportar de um lugar a outro (e de lugar a outro)                  | 1 2 3 4 5          |       |       |       |             |
| 21. Atividades recreativas que exigem peuo esforço (por exemplo: jogar cartas, etc.) | 1 2 3 4 5 |       |       |       |             |

22. Na semana passada, em vez de passar o seu problema com bravo, ombro ou mão, sente sua atividade normal para familiares, amigos, vizinhos ou colegas?

| Não deixa de fazer | Pouso | Média | Muito | Extremamente |
|--------------------|-------|-------|-------|-------------|
| 1 2 3 4 5          |       |       |       |             |

23. Durante a semana passada, seu trabalho ou atividades diárias mais raramente teve limitação devido ao seu problema com bravo, ombro ou mão?

Nenhuma | Pouso | Média | Muito | Extremamente |
|--------|-------|-------|-------|-------------|
| 1 2 3 4 5 |       |       |       |             |

24. Durante a semana passada, seu bravo, ombro ou mão quando você fale?

| Não deixa de fazer | Pouso | Média | Muito | Extremamente |
|--------------------|-------|-------|-------|-------------|
| 1 2 3 4 5          |       |       |       |             |

25. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

26. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

27. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

28. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

29. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

30. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

31. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

32. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

33. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

34. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

35. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

36. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

37. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

38. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

39. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

40. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

41. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

42. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

43. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

44. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

45. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

46. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

47. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

48. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

49. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

50. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

51. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

52. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

53. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

54. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

55. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

56. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

57. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

58. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

59. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

60. Durante a semana passada, seu bravo, ombro ou mão quando você fale? 1 2 3 4 5 |

Para o cálculo dos escores DASH, deve-se utilizar a seguinte fórmula: Somando as notas dos 20 primeiros questionares – 2011.2

Para o cálculo dos escores dos médicos opcionais, estes devem ser calculados separadamente, utilizando a seguinte fórmula: Soma de valores – 2011.16
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