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Original Article

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

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ABSTRACT

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.

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

Palavras-chave:
Fixação de fratura
Fixação interna de fraturas
Fraturas da falange proximal

RESUMO

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

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submetidos ao tratamento cirúrgico minimamente invasivo com parafuso intramedular (Acutrak®). Esses pacientes foram avaliados 12 meses após a cirurgia por meio do questionário DASH de qualidade de vida, escala de dor VAS, arco de movimento (adm em graus) e avaliação radiográfica.

Resultados: Todos os pacientes obtiveram redução adequada e consolidação das fraturas. Houve melhoria estatisticamente significativa da qualidade de vida (DASH), escala de dor (VAS) e arco de movimento.

Conclusão: A técnica minimamente invasiva no tratamento das fraturas instáveis e extra-articulares da falange proximal com o parafuso intramedular Acutrak® é eficaz e segura e apresenta resultados clínico-funcionais satisfatórios.

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,[6] 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®) 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® 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® screw, following the intramedullary tutor principle, in order to stabilize the fracture of the proximal phalange.

Operative technique for osteosynthesis using an Acutrak® 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

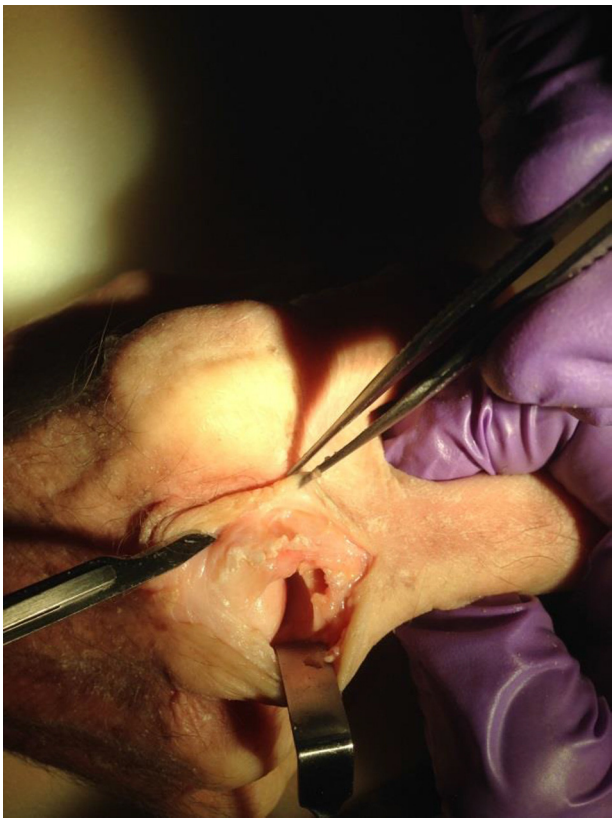


Fig. 1 – View of the entry point of the screw at the dorsal base of the proximal phalanx, showing the preservation of the joint cartilage at the base of the proximal phalanx, in the metacarpophalangeal joint. Dissection of a cadaver.

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 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.

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.

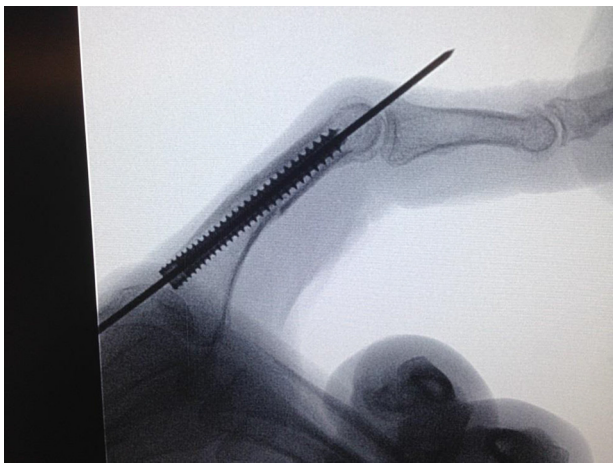


Fig. 2 – Postoperative radiograph in lateral view of patient 27.

Fig. 3 – Postoperative radiograph in anteroposterior view of patient 27.

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).

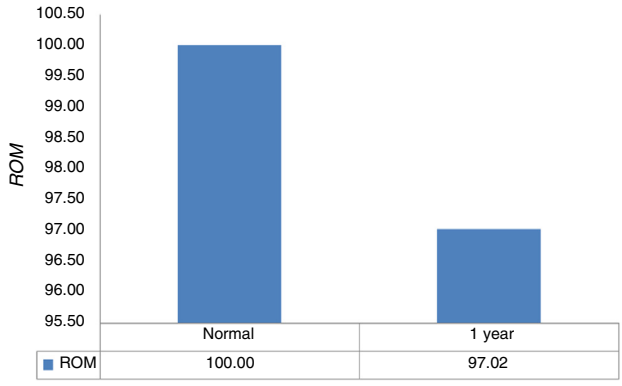
In comparing the clinical and functional results with those of the unaffected side (range of motion, DASH and VAS), we observed that there was no statistically significant difference between the values analyzed, which showed that functional recovery of the fingers affected had been achieved.

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

Table 2 – Comparison of the variables of interest at the preoperative and postoperative observation times.

Pair of variables	*n*	Mean	Standard deviation	Minimum	Maximum	25th percentile	50th percentile (median)	75th percentile	Significance (*p*)
Normal ROM	48	100.0	0.00	100.0	100.0	100.0	100.0	100.0	0.002
ROM after 1 year	48	97.02	7.02	65.0	100.0	96.25	100.0	100.0	
Normal DASH	48	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.002
DASH after 1 year	48	3.56	7.00	1.00	45.0	1.00	1.00	4.00	
Normal VAS	48	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.002
VAS after 1 year	48	1.52	1.11	1.00	6.00	1.00	1.00	1.75	

Source: Hospital service files.



Source: Hospital service files

Fig. 4 – Comparison of the range of motion (ROM) variable between the normal and affected fingers (%). Source: Hospital service files.

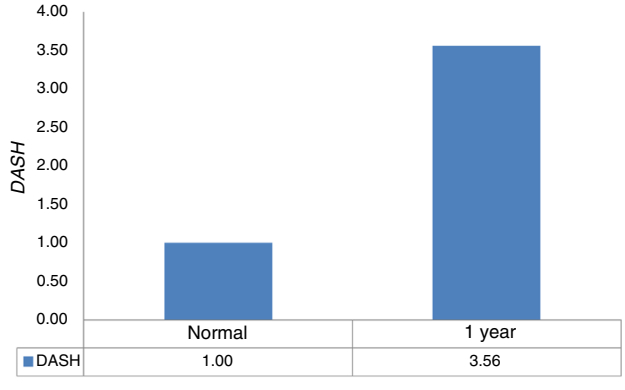
in the middle phalanx, perhaps because of the great length of the screw. It was removed after the fracture had consolidated, and this improved the pain. The length of follow-up was 17 months, with a minimum of 12 and maximum of 36. The mean age was 30 years, with a minimum of 19 and maximum of 51.

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.[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.[11–14]

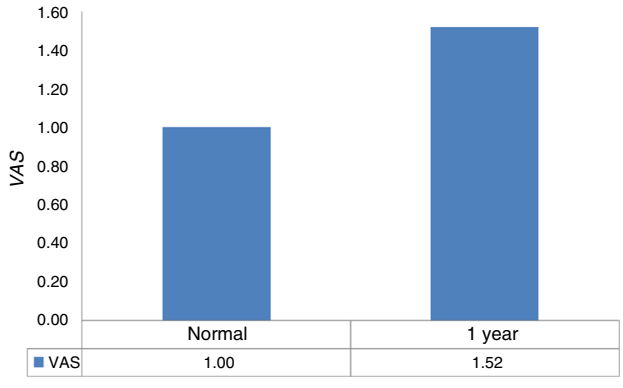
For this purpose, a variety of means have been developed, such as the new 1.5 or 2 mm specific locking plates with a minimum thickness of 2 or 3 mm, in association with guiding tools and reducing tweezers that are extremely precise. The Acutrak® self-compressing screw, which was designed previously for 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,[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.[16–18]



Source: Hospital service files

Fig. 5 – Comparison of the DASH variable between the normal and affected sides. Source: Hospital service files.



Source: Hospital service files

Fig. 6 – Comparison of the VAS variable between the normal and affected sides. Source: Hospital service files.

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.,[17] 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.[18] 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.[11,12,16,19]

With regard to evaluating the complications, the study by Yan et al.[16] showed worse functional results and a higher complication rate among patients treated using conventional techniques. Among the complications, edema, pseudarthrosis, 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,[20] 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.,[14] 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.[21,22] However, in relation to the humerus, conservative treatment and use of percutaneous bridging plates presented lower complication rates.[23]

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)[24] 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.

Esse questionário é sobre seus sintomas, assim como suas habilidades para fazer certas atividades.
Por favor, responda a todas as questões baseando-se na sua condição na semana passada.
Se você não teve a oportunidade de fazer uma das atividades na semana passada, por favor, tente estimar qual resposta seria a mais correta.
Não importa qual mão ou braço você usa para fazer a atividade; por favor, responda baseando-se na sua habilidade independentemente da forma como você faz a tarefa.

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

	Não houve dificuldade	Houve pouca dificuldade	Houve dificuldade média	Houve muita dificuldade	Não conseguiu fazer
1. Abrir um vidro novo ou com a tampa muito apertada	1	2	3	4	5
2. Escrever	1	2	3	4	5
3. Virar uma chave	1	2	3	4	5
4. Preparar uma refeição	1	2	3	4	5
5. Abrir uma porta pesada	1	2	3	4	5
6. Colocar algo em uma prateleira acima de sua cabeça	1	2	3	4	5
7. Fazer tarefas domésticas pesadas (por exemplo: lavar paredes, lavar o chão)	1	2	3	4	5
8. Fazer trabalho de jardinagem	1	2	3	4	5
9. Arrumar a cama	1	2	3	4	5
10. Carregar uma sacola ou uma maleta	1	2	3	4	5
11. Carregar um objeto pesado (mais de 5 kg)	1	2	3	4	5
12. Trocar uma lâmpada acima da cabeça	1	2	3	4	5
13. Lavar ou secar o cabelo	1	2	3	4	5
14. Lavar suas costas	1	2	3	4	5
15. Vestir uma blusa fechada	1	2	3	4	5
16. Usar uma faca para cortar alimentos	1	2	3	4	5
17. Atividades recreativas que exigem pouco esforço (por exemplo: jogar cartas, tricotar)	1	2	3	4	5
18. Atividades recreativas que exigem força ou impacto nos braços, ombros ou mãos (por exemplo: jogar vôlei, martelar)	1	2	3	4	5
19. Atividades recreativas nas quais você move seu braço livremente (como pescar, jogar peteca)	1	2	3	4	5
20. Transportar-se de um lugar a outro (ir de um lugar a outro)	1	2	3	4	5
21. Atividades sexuais	1	2	3	4	5

	Não afetou	Afetou pouco	Afetou medianamente	Afetou muito	Afetou extremamente
22. Na semana passada, em que ponto o seu problema com braço, ombro ou mão afetou suas atividades normais com família, amigos, vizinhos ou colegas?	1	2	3	4	5

	Não limitou	Limitou pouco	Limitou medianamente	Limitou muito	Não conseguiu fazer
23. Durante a semana passada, o seu trabalho ou atividades diárias normais foram limitadas devido ao seu problema com braço, ombro ou mão?	1	2	3	4	5

Meça a gravidade dos seguintes sintomas na semana passada:	Nenhuma	Pouca	Mediana	Muita	Extrema
24. Dor no braço, ombro ou mão	1	2	3	4	5
25. Dor no braço, ombro ou mão quando você fazia	1	2	3	4	5
27. Fraqueza no braço, ombro ou mão	1	2	3	4	5
28. Dificuldade em mover braço, ombro ou mão	1	2	3	4	5

	Não houve dificuldade	Pouca dificuldade	Média dificuldade	Muita dificuldade	Tão difícil que você não pôde dormir
29. Durante a semana passada, qual a dificuldade que você teve para dormir por causa da dor no seu braço, ombro ou mão?	1	2	3	4	5

	Discordo totalmente	Discordo	Não concordo nem discordo	Concordo	Concordo totalmente
30. Eu me sinto menos capaz, menos confiante e menos útil por causa do meu problema com braço, ombro ou mão	1	2	3	4	5

As questões que se seguem são a respeito do impacto causado no braço, ombro ou mão quando você toca um instrumento musical, pratica esporte ou ambos.
Se você toca mais de um instrumento, pratica mais de um esporte ou ambos, por favor, responda com relação ao que é mais importante para você.
Por favor, indique o esporte ou instrumento que é mais importante para você: _____
☐ Eu não toco instrumentos ou pratico esportes (você pode pular essa parte)

Por favor circule o número que melhor descreve sua habilidade física na semana passada. Você teve alguma dificuldade para:	Fácil	Pouco difícil	Dificuldade média	Muito difícil	Não conseguiu fazer
1. Uso de sua técnica habitual para tocar instrumento ou praticar esporte?	1	2	3	4	5
2. Tocar o instrumento ou praticar o esporte por causa de dor no braço, ombro ou mão?	1	2	3	4	5
3. Tocar seu instrumento ou praticar o esporte tão bem quanto você gostaria?	1	2	3	4	5
4. Usar a mesma quantidade de tempo tocando seu instrumento ou praticando o esporte?	1	2	3	4	5

As questões seguintes são sobre o impacto do seu problema no braço, ombro ou mão em sua habilidade em trabalhar (incluindo tarefas domésticas se este é seu principal trabalho).
Por favor, indique qual é o seu trabalho: _____
☐ Eu não trabalho (você pode pular essa parte)

Por favor, circule o número que melhor descreve sua habilidade física na semana passada. Você teve alguma dificuldade para:	Fácil	Pouco difícil	Dificuldade média	Muito difícil	Não conseguiu fazer
1. Uso de sua técnica habitual para seu trabalho?	1	2	3	4	5
2. Fazer seu trabalho usual por causa de dor em seu braço, ombro ou mão?	1	2	3	4	5
3. Fazer seu trabalho tão bem quanto você gostaria?	1	2	3	4	5
4. Usar a mesma quantidade de tempo fazendo seu trabalho?	1	2	3	4	5

Cálculo do escore do DASH

Para se calcular o escore das 30 primeiras questões, deverá ser utilizada a seguinte fórmula:
(Soma dos valores das 30 primeiras questões - 30)/1,2

Para o cálculo dos escores dos módulos opcionais, estes deverão ser calculados separadamente, utilizando a seguinte fórmula:
(Soma dos valores - 4)/0,16

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