Traumatic Injuries to the Hand From the Use of an Angle Grinder. A Problem in Our Field

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ABSTRACT

Introduction: Hand injuries caused by angle grinders are frequent and generally take place among young adults. In developing countries, the domestic and informal work environments are the most frequent places where this could happen. The present study is aimed at describing associated factors to these types of injuries. Lesions were quantified and classified according to the severity and anatomic region of the hand involved. **Methods:** An epidemiologic, retrospective study was performed between 2016 and 2020. The patients' level of education, previous experience using the machine, use of personal protective equipment (PPE), sex, and age were analyzed. To determine the pattern of the injuries, a clinical-anatomical and a detailed and individualized radiological analysis were performed on each patient. The severity was measured using the "Hand Injury Severity Score" (HISS). **Results:** 928 patients were studied (920 men, 8 women, average age of 42 years [range 18-67]). Only 22.4% were wearing PPE at the time of the accident. 776 participants were performing tasks for which the tool was not intended (84.5%). The left hand was the most affected (60%). In 784 patients, the injuries involved their fingers (84.48%); the predominant pattern was the index and middle finger (55%). According to the HISS, 24.1% were minor injuries, 41.3% were moderate, 26% were serious, and 8.6% were severe. **Conclusions:** Injuries caused by an angle grinder can be devastating. We believe that an epidemiological update is likely to increase the need to develop preventive methods to decrease its high incidence.

Keywords: Angle grinder; traumatic injuries; hand; epidemiology.

Level of Evidence: IV

Lesiones traumáticas en la mano por el uso de amoladora. Un problema en nuestro medio

RESUMEN

Introducción: Las lesiones en las manos causadas por amoladora son comunes y generalmente ocurren en adultos jóvenes. En países en desarrollo, el ámbito doméstico y el trabajo informal son los escenarios más frecuentes. El objetivo de este estudio fue describir factores asociados a las lesiones por amoladora, y cuantificar y clasificar las heridas, según la gravedad y la región anatómica de la mano involucrada. **Materiales y Métodos:** Se realizó un estudio epidemiológico, retrospectivo. Entre 2016 y 2020, estudiamos a los pacientes con heridas de mano causadas por amoladora. Se analizaron el nivel educativo, la experiencia con la herramienta, el material cortado, el uso de equipo de protección personal, la edad y el sexo. Para determinar el patrón de las lesiones se realizó un análisis clínico-anatómico y radiológico detallado e individualizado. La gravedad fue evaluada con el *Hand Injury Severity Score*. **Resultados:** Se evaluó a 928 pacientes (920 hombres y 8 mujeres, edad promedio 42 años). Solo el 22,4% usaba equipo de protección personal en el momento del accidente. El 83,5% (776 casos) realizaba tareas inusuales para la que esta herramienta no fue diseñada. La mano más afectada fue la izquierda (62,06%). En 784 pacientes, las heridas involucraban los dedos, el patrón de asociación predominante fue entre el 2do y 3er dedo (54,44%). Las lesiones fueron leves (24,1%), moderadas (41,3%), graves (26%) y mayores (8,6%). **Conclusiones:** Las lesiones por amoladora pueden resultar devastadoras. Una actualización epidemiológica reforzaría la necesidad de desarrollar métodos preventivos con el fin de disminuir su alta incidencia.

Palabras clave: Amoladora; lesiones traumáticas; mano; epidemiología.

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INTRODUCTION

Hand injuries caused by angle grinders are common and usually occur in young adults. They are characterized by a highly variable extension and distribution. These injuries have a significant impact on activities of daily living, as well as physical functions, which affect socioeconomic aspects.[1]

In addition to occurring in a work context, they also occur during different activities of daily living. In developing countries, the domestic sphere and informal work are the most frequent scenarios. The underreporting of this type of injury is common due to the high unemployment rate and the deficiencies of the legislation on work safety and health.[2,3]

Dysfunctional tool use, lack of personal protective equipment (PPE), distraction, fatigue, and performing unusual tasks are associated with serious and disabling injuries.[4] A 2003 Australian case report indicated that less than 5% of patients presenting with angle grinder injuries reported using appropriate PPE.[5]

In our region, the angle grinder is associated with one of the highest rates of injury per hour of use.[6]

In 2004, Frank et al. described the injuries to the hand caused by the use of the circular saw, with an interesting analysis from which it can be deduced that the most frequent injuries affect the fingers, in general, at least two of them, with a predominance of the thumb and the index finger. In turn, with the increase in the number of affected fingers, the level of the lesion was closer to the proximal phalanx. In the majority of cases in which a finger was amputated, the adjacent fingers were affected.[7]

We conducted an extensive literature search and were unable to find a study that described, in detail, the spectrum of injuries caused by angle grinder and questions remain about which modifiable risk factors should preventive measures focus on.

The large number of patients admitted to our hospital with injuries caused by this tool and the wide variety of injury patterns we have treated motivated us to undertake this study.

Objective

We set out to describe factors associated with angle grinder injuries, and to quantify and classify the injuries, according to the anatomical region of the hand involved and the severity.

MATERIALS AND METHODS

We conducted a retrospective, descriptive, cross-sectional cohort study. Between 2016 and 2020, we registered all patients admitted to the Emergency Department of our hospital with hand injuries caused by a angle grinder. The inclusion criteria were: acute injuries caused by a angle grinder in a domestic or informal work environment, that had affected the hand(s) and finger(s), understanding the area of the body to be studied as the anatomical region distal to an imaginary line between the eminences of the carpal, pisiform, and scaphoid bones. We excluded patients with wounds caused by another cause or involving another anatomical region, injuries with more than seven days of evolution, workers in a regulated environment under biosafety standards and those with insufficient or no contact data.

All the patients included in the study were in the database of our hospital, and they were contacted and notified about their participation. An informed consent was designed for their registration and a questionnaire was prepared with basic questions from which the following variables to be analyzed emerged: age, sex, educational level, time and place of the incident, background in the use of this tool, material that was being cut, and use of protection elements at the time of the accident. Other variables analyzed were injury patterns and their severity. To determine the type and pattern of the lesions, we performed a detailed and individualized clinical-anatomical and radiological analysis.

The severity of the injuries was evaluated with the Hand Injury Severity Score (HISS) (Tables 1 and 2).[8] This system evaluates damage to the skin and to musculoskeletal and neural structures. We calculated it for each case and grouped the cases as: minor (HISS <20), moderate (HISS 21-50), severe (HISS 51-100) or major (HISS >101) injury.

According to the Argentine Ministry of Production and Labor,[9] the PPE that a worker should use for this type of work is: protective footwear, gloves, helmet, goggles, and protective clothing suitable for cuts. Since the hands are the anatomical region involved in this study, we only considered the use of gloves when referring to PPE in our patients.

Table 1. *Hand Injury Severity Score* (HISS)

Integuments				
Skin loss	Absolute values (hand)	Dorsum	<1 cm^2	5
			>1 cm^2	10
			>5 cm^2	20
		Palm	Dorsum x 2	
	Weight values (digital)	Dorsum	<1 cm^2	2
			>1 cm^2	3
		Finger pulp	<25%	3
			>25%	5
Skin laceration			<1 cm	1
			>1 cm	2
Nail injury				1
Skeletal				
Fractures	Diaphyseal fractures			1
	Comminuted diaphyseal fracture			2
	Distal interphalangeal intra-articular fracture			3
	Intra-articular proximal interphalangeal fracture			5
	Intra-articular metacarpophalangeal joint fracture			4
Dislocations	Open			4
	Closed			2
Ligament injury	Sprain			2
	Tear			3
Motor				
Extensor tendon	Proximal to proximal interphalangeal			1
	Distal to proximal interphalangeal			3
Deep flexor	Zone 1			6
	Zone 2			6
	Zone 3			5
Superficial flexor				2
Neural				
Absolute values	Recurrent branch of the median nerve			30
	Deep ulnar branch			30
Weight values	Digital nerve x 1			3
	Digital nerve x 2			4

Table 2. Individual digital weighting factors

Finger	Weighting factor
Thumb	x 6
Index	x 2
Middle	x 3
Ring	x 3
Pinkie	x 2

RESULTS

Of a total of 1062 patients, 134 could not be contacted and were therefore excluded from the study, 928 met the inclusion criteria: they were 920 men (99.13%) and eight women (0.86%), with a mean age of 42 years (range 18-67).

Most patients reported that they were cutting wood at the time of the accident (84.5%), marking a wide difference with the rest of the materials (metals 12.1% and ceramics 3.4%). Only 22.4% declared using PPE when they suffered the accident, while the rest did not use protection.

With regard to educational level, only 46 patients had university or tertiary education (4.96%), 375 had not completed secondary education (40.41%), and 415 had completed it (44.72%), 91 patients had completed their primary studies (9.81%) and only one was illiterate (0.1%).

In the interview, 25.9% of those surveyed reported having used the angle grinder for the first time, while the rest said they had used it before. When analyzing the time records, it was observed that a large number of accidents (72.4%) occurred during the afternoon (between 12:00 and 8:00 p.m.). The day with the highest incidence in our study was Friday (27.6%) (Figures 1 and 2).

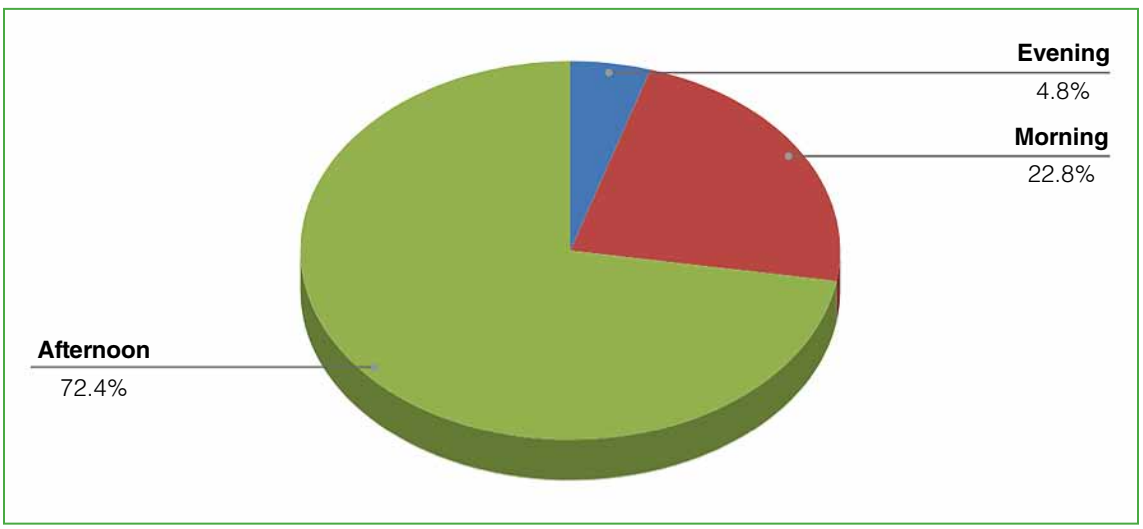

Figure 1. Distribution of traumatic events according to the time of day in which they occurred.

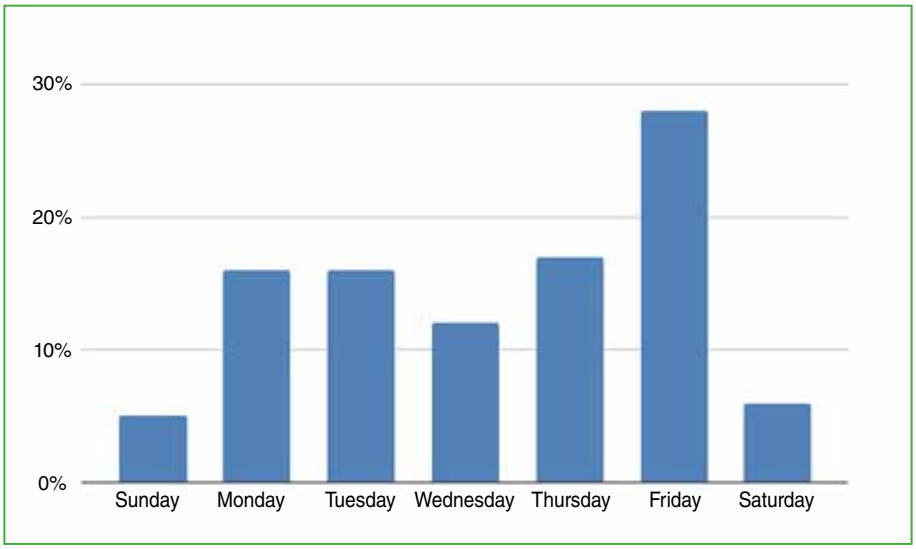

Figure 2. Incidence of injuries according to the day of the week.

36.21% (336 patients) suffered injuries to the right hand, 576 (62.07%) to the left hand, and 16 to both hands (1.72%). 84.48% of the injuries (784) involved the fingers, in 448 of these (48.27%) only one finger was affected, and there was a predominance of the thumb (57.14%), followed by the index (35.7%) (Figure 3).

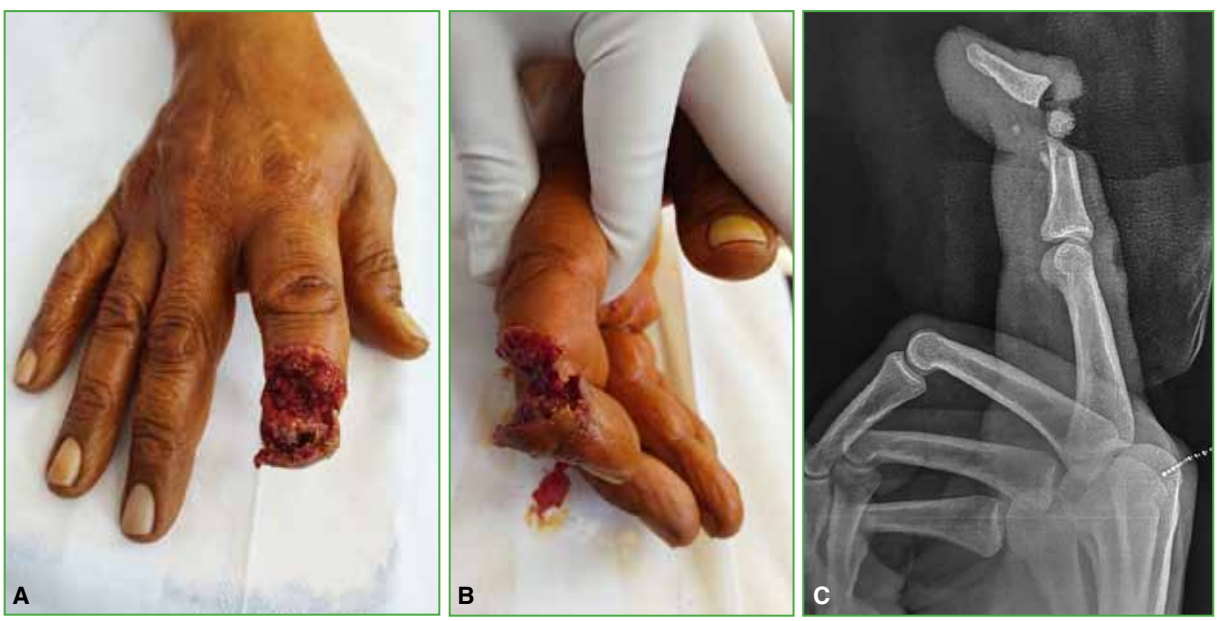

Figure 3. A. Serious injury to the index finger of the right hand, dorsal view. **B.** Serious injury to the index finger of the right hand, lateral view. **C.** Radiograph of the index finger, lateral view. A fracture of the second phalanx is observed.

In 336 cases, there was more than one affected finger (36.2%), the combination of two fingers was the most common (52.38%). 13.8% (128 patients) had four fingers involved during the accident (Figure 4), and only 32 patients (3.45%) suffered injuries to three fingers. There were no cases involving the five fingers. The predominant pattern was the association between the index and middle fingers (54.44%). The rest of the combinations did not show significant differences in the frequency of presentation (Figure 5).

Figure 4. A. Serious hand injury involving four fingers at different levels, dorsal view. **B.** Serious hand injury involving four fingers at different levels, palmar view.

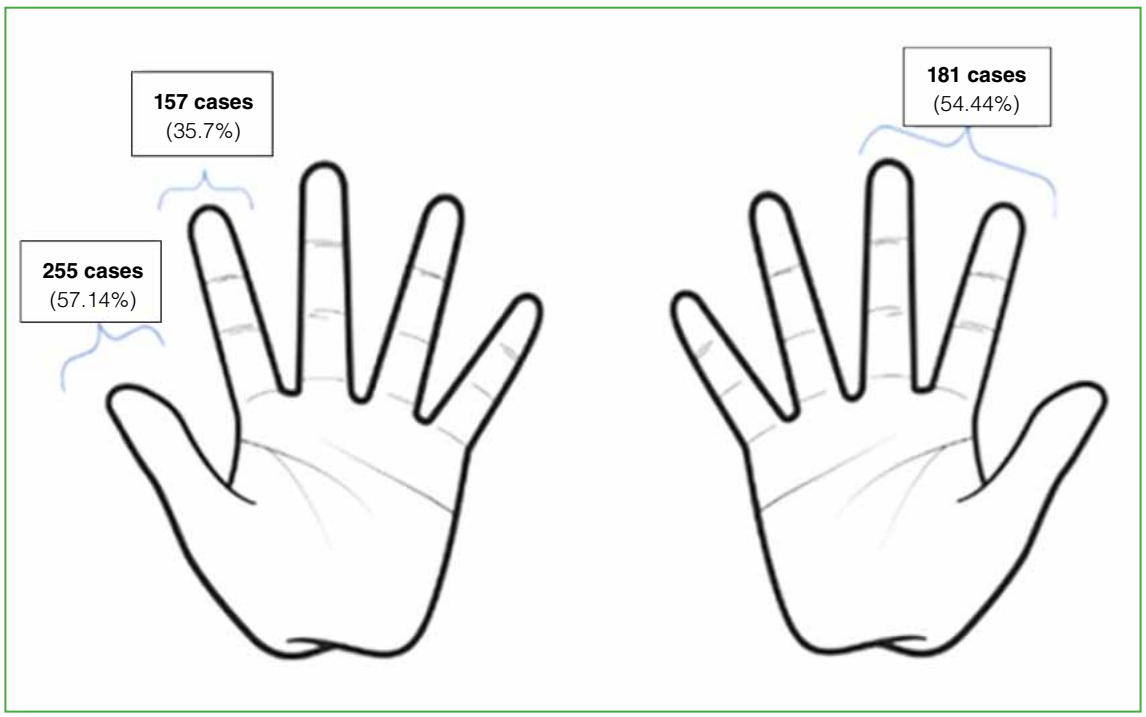

Figure 5. Diagram of injuries.

Traumatic amputations only affected the fingers, and represented 15.51% (144 patients). The middle finger was the most prevalent (41.67%), and the level of amputation was higher in the second phalanx for this finger (60%) (Figure 6).

Figure 6. A. Serious hand injury with compromise of the three central fingers plus amputation of the middle finger at the level of the second phalanx, dorsal view. **B.** Palmar view. **C.** Anteroposterior radiograph of the hand showing the amputation of the middle finger at the level of the second phalanx and the comminuted fracture of the ring finger at the level of the second phalanx.

Of the total number of registered patients, 240 suffered fractures of at least one bone, all of which were considered open. Our findings show that the bone involvement of the index finger and thumb was the most prevalent in order of frequency (Table 3). In the index finger, the involvement of the second phalanx predominated (75.53%) while in the thumb, first phalanx involvement was the most frequent (80.5%). The metacarpal bones were affected in 3.45% of the injured and there were no differences between the frequency of presentation.

Table 3. Total sectorized fractures according to affected finger and phalanx

Finger	1st Phalanx	2nd Phalanx	3rd Phalanx	Total
1°	58	14		72
2°	10	66	15	91
3°	0	29	7	36
4°	8	27	1	36
5°	1	1	5	7
				240

Regarding the severity of the injuries, the HISS score was taken into account when evaluating the involvement of each wound, including tendon injuries (we found 659 injuries: 371 involved extensor tendons and 288, flexor tendons), neurological and vascular involvement (96 and 32 cases, respectively), and whether the injury was to the hand or only to the fingers. We determined that 24.1% were minor injuries; 48.3%, moderate injuries; 19%, serious; and 8.6% severe.

DISCUSSION

Hand injuries are of great importance because it is an anatomical region of exceptional value, due to its use in almost all professions and occupations.[10]

According to our findings, we found some similarities and differences with the literature regarding the pattern of lesions. In accordance with what was described by Frank et al., the most frequently injured hand was the left (62.02%).[7] In turn, when the fingers were involved, in isolation, the most affected was the thumb, followed by the index. We found a difference in the pattern of prevalent injury, in their investigation, the association between the index and middle fingers was the most frequent. However, in our study, the association between the index and middle fingers was the prevalent combination.

Regarding the severity of the injuries, the moderate ones prevailed (48.3%). The serious (19.0%) and severe (8.6%) injuries, together with the moderate ones, far exceed the percentage of minor injuries (24.1%), which allowed us to confirm that the injuries produced by this tool are, for the most part, disabling for the patient.[11]

Temporary and transient factors (including time and time of day) can combine under different conditions to synergistically trigger injury. According to the literature, the highest frequency of injuries occurred during the morning (between 8:00 and 12:00)[12] but, in our study, the most frequent time was during the afternoon (between 12:00 and 20:00).

As described by Chow et al. or Ribak et al., most accidents occurred between Monday and Friday, with a marked decrease on Saturday and Sunday.[13,14]

Regarding PPE, there is controversy among the authors about the efficacy of its use, due to the different mechanisms and types of wounds. For their part, Sorock et al.[15] maintained that the implementation of the use of gloves managed to reduce the relative risk of damage to the hand by up to 60%, and that their use was identified as a significant protection factor. On the contrary, other current authors assert that their use could cause discomfort when handling the tool and be associated with a high risk of injury.[16] Stewart et al.[17] stated that gloves have a protective factor in terms of minor injuries, but they do not prevent more severe injuries. Only 22.4% of our patients reported using PPE at the time of the accident and suffered the most diverse injuries, minor injuries being the least frequent (30.7%).

A angle grinder is a power tool used to cut, reduce size, or polish various items, including stone, concrete, metal, wood, and ceramics, among others. The angle grinder has a disc that rotates between 6,000 and 15,000 times per minute. When used incorrectly, it can cause severe trauma.[6] Using unusual equipment for the task at hand is a transient risk factor.[18] It is important to emphasize that the use of a tool such as a angle grinder on jobs for which it was not intended is one of the most important risk factors that we have found. The most frequent pattern was the use of the angle grinder to cut wood or firewood, and it was the main cause for all kinds of injuries. These occur due to a "kickback" of the disc from the surface, causing the sharp blade to come directly at the user. Additionally, an inexperienced operator may choose the wrong blade for the type of substrate being cut, further increasing the risk of accidents.[19,20] We also note that using the wrong size, worn, or chipped blade increases probability that it will break or jam.[21]

The strengths of our study are the sample size and the detailed record of injury patterns. On the other hand, the weaknesses are its retrospective nature and also the heterogeneity of the variables analyzed.

CONCLUSIONS

In our field, angle grinder injuries are common and can be devastating. In this study, 84.5% of the patients were cutting wood or firewood when they suffered the accident. The easy access to this tool and its various discs, as well as the insistence on the part of users to use it to cut this material, are key factors in the production of injuries.

We believe that an epidemiological update would reinforce the need to develop preventive methods and provide greater training to users in order to reduce its high incidence.

Conflict of interests: The authors declare no conflicts of interest.

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