






## Hierarchical clustering of the demographic, clinical profile and handgrip strength of patients after distal radius fracture

### Agrupamento hierárquico do perfil demográfico, clínico e da força de preensão palmar dos pacientes após fratura distal do rádio

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#### ABSTRACT

**Objective:** The aim of this study was to identify the profiles of patients after distal radius fracture treatment grouped according to demographic and clinical factors, and grip strength on the fracture contralateral side. **Method:** This was a retrospective and cross-sectional single-center study that included 141 patients with unilateral distal radius fractures treated at a public hospital by the physical therapy service. **Results:** Demographic and clinical data from all patients included in this study were collected from patients' medical records. Grip strength was assessed between 8 and 10 weeks after the fracture. We performed an exploratory multivariate analysis using Multiple Correspondence Analysis (MCA) followed by Agglomerative Hierarchical Cluster Analysis (AHC). Numerical values of coordinates of all the dimensions obtained in MCA were used as input variables in the cluster analysis and the perceptual map of hierarchical clustering (Dendrogram) was obtained. We highlighted three groups based on cluster analysis. One group included men, aged 18 to 59 years, with fractures either on the right or left side, trauma caused by traffic accidents or other causes, surgical treatment and normal grip strength on the contralateral side. The second group had women, aged 60 to 90 years, fracture resulting from falls from their own height, conservative treatment and intermediate grip strength on the contralateral side. The third group had only the weak grip strength on the contralateral side. **Conclusion:** This cluster analysis revealed three profiles of patients during the early period after distal radius fracture treatment.

**Keywords:** Orthopedic Procedures, Physical Therapy Modalities, Wrist Fractures, Hand Strength

#### RESUMO

**Objetivo:** Identificar o perfil de pacientes após o tratamento de fraturas distais do rádio, agrupados de acordo com fatores demográficos, clínicos e a força de preensão palmar do lado contralateral. **Método:** Trata-se de um estudo retrospectivo e transversal realizado em um único centro, que incluiu 141 pacientes com fraturas do rádio distal, atendidos no serviço de fisioterapia de um hospital público. **Resultados:** Os dados demográficos e clínicos de todos os pacientes incluídos neste estudo foram coletados dos prontuários dos pacientes e a força de preensão foi avaliada entre a 8ª e 10ª semanas após a fratura. Foi realizada uma análise multivariada exploratória utilizando Análise de Correspondência Múltipla (ACM), seguida de Análise de Agrupamento Hierárquico (AAH). Os valores das coordenadas de todas as dimensões obtidas na ACM foram utilizados como variáveis de entrada na análise de cluster e o mapa perceptual de agrupamento hierárquico foi obtido. Destacamos três grupos: um grupo incluía homens, com idade entre 18 e 59 anos, com fraturas no lado direito ou esquerdo, trauma causado por acidentes de trânsito ou outras causas, tratamento cirúrgico e força de preensão normal no lado contralateral; segundo grupo era composto por mulheres, com idade entre 60 e 90 anos, fratura resultante de quedas de sua própria altura, tratamento conservador e força de preensão intermediária no lado contralateral. O terceiro grupo apresentava apenas fraqueza na força de preensão no lado contralateral. **Conclusão:** Esta análise de cluster revelou três perfis de pacientes durante o período inicial após o tratamento de fraturas distais do rádio.

**Palavras-chaves:** Procedimentos Ortopédicos, Modalidades de Fisioterapia, Fraturas do Punho, Força da Mão

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#### Conflict of Interests

Nothing to declare

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## INTRODUCTION

Distal radius fracture (DRF) is one of the most common types of all fractures and it more frequently affects elderly women, boys and young men.<sup>1,2</sup> The evaluation of results after a DRF is usually measured by radiological parameters,<sup>3</sup> and general physical examination, such as pain intensity, hand function, wrist range of the motion and grip strength.<sup>4</sup>

Grip strength is considered a valuable tool in the context of distal radius fractures, providing crucial information for a comprehensive and personalized approach of treatment and rehabilitation, as well as an index of recovery following DRF repair.<sup>5</sup> The fracture contralateral side is used as a parameter to assess grip strength recovery. Brogren et al.<sup>6</sup> found that, one year after surgery, the average grip strength on the injured side was 88% of that on the contralateral side, indicating a significant reduction. Nevertheless, no significant disparity in grip strength was observed between the injured side and the health side, even at the 2 to 4 years postoperative mark.

The measurement of grip strength is employed in various contexts and it is a reliable and valuable procedure among healthy participants as well as in various clinical populations.<sup>7</sup> It serves as a crucial factor in determining hand function and dexterity,<sup>8</sup> and can be indicative of overall muscle strength in both younger and older individuals.<sup>9,10</sup> Grip strength is crucial for performing activities of daily living (ADLs) and should be regarded as a vital sign for routine assessment.<sup>10</sup>

According to Bohannon<sup>11</sup> grip strength has been considered a biomarker. Evidence has shown that grip strength serves as a valuable indicator for various health aspects, including overall strength, upper limb function, bone mineral density, fractures, falls, malnutrition, cognitive impairment, depression, sleep problems, diabetes, multimorbidity, and quality of life.<sup>11</sup> Additionally, there is evidence supporting its predictive role in outcomes such as all-cause and disease-specific mortality, future function, bone mineral density, fractures, cognition, depression, and issues related to hospitalization.<sup>11</sup>

Understanding the profile of patients after distal radius fracture, including grip strength on the contralateral side of the fracture, can assist the professional in directing medical or physiotherapeutic treatment strategies, considering all factors associated with the individual. Consequently, this can provide appropriate treatment from the initial phase of care. Therefore, the aim of this study was to identify the profiles of patients after distal radius fracture treatment, grouped according to demographic and clinical factors, and grip strength on the fracture contralateral side.

## OBJECTIVE

The aim of this study was to identify the profiles of patients after distal radius fracture treatment, grouped according to demographic and clinical factors, and grip strength on the fracture contralateral side.

## METHOD

This was a retrospective and cross-sectional single-center study that included clinical recorded data of patients with unilateral distal radius fractures who were assisted by the physical therapy service of Hand and Upper Limb Clinic of a University Public Hospital. This tertiary care hospital provides access to qualified

services to the population free of charge.

The patients' data were collected from their medical records from the physical therapy service from January 2015 to December 2019. A convenience sample (a non-probability sampling method) was selected based on the following eligibility criteria: age above 18 years, unilateral distal radius fracture, and complete information present in the patient records related to demographic and clinical data, as well as grip strength measurements performed between the 8<sup>th</sup> and 10<sup>th</sup> weeks after the fracture, or after the consolidation of the fracture confirmed by the doctor. This study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for observational studies and received approval from the University Ethics Committee registered at CAAE: 32351420.5.0000.5154.

## Demographic and clinical outcomes

Demographic and clinical data were collected from all patients included in the study by two researchers (two authors of this study). Demographic information encompassed sex (male or female), age, dominant side (right or left), profession (heavy manual worker or office worker), while clinical data included fracture side, cause of trauma (fall from own height, traffic accident and other causes), clinical treatment (surgical or conservative) and type of treatment (cast, open reduction internal fixation, external fixation, pins or combination of treatments). Sex was categorized as female or male and defined as a biological attribute ('sex assigned at birth').<sup>12</sup>

## Grip strength outcomes

The measurement data of the patients contained in the clinical records were extracted by the same researchers mentioned above, while the data from grip strength was collected by a physiotherapist responsible for the physical therapy service. Grip strength was assessed using Jamar<sup>®</sup> dynamometer (5030J1 Patterson Medical Jamar Hydraulic Hand Dynamometer). To collect the measurement data, patients remained seated with adducted shoulder, elbow flexed at 90°, forearm in a neutral position, and wrists in slight extension, following the recommendations of the American Society of Hand Therapy (ASHT).<sup>13</sup>

Grip strength was measured on both sides with three measurements collected, with an interval of fifteen seconds between them, and the arithmetic mean among measurements was calculated.<sup>14</sup> The grip position adopted for the measures was the second position.<sup>15</sup> In order to ensure that the subjects were providing their best effort during grip testing,<sup>16</sup> a verbal command was given by the examiner ("Squeeze!, Harder!, Harder!, Relax!").<sup>17</sup>

The Jamar dynamometer was previously calibrated. Grip strength outcomes included the grip strength of fracture side, grip strength of contralateral side, and gripping ratio. The ratio was calculated by dividing the grip strength in the injured hand by the grip strength in the non-injured hand<sup>18</sup> in order to normalize the grip data and assess the percentage of grip strength on the fracture side in relation to the contralateral side. Palmar grip strength was categorized as normal ( $\geq 32$  kg for men and  $\geq 20$  kg for women) and weak ( $<26$  kg for men and  $<16$  kg for women).<sup>19,20</sup>

## Statistical analysis

The data were summarized through descriptive analysis. For numerical variables, the mean and standard deviation were

calculated, and for categorical variables, absolute and relative frequencies were computed.

An exploratory multivariate analysis was conducted to classify the correspondence among demographic and clinical features and grip strength of patients during the early period after distal radius fracture treatment. The Multiple Correspondence analysis (MCA) followed by Agglomerative Hierarchical Cluster analysis (AHC) were performed as the methods to investigate the association among the several categorical variables.<sup>21</sup> The numerical values of coordinates of all the dimensions obtained in MCA were used as input variables in the cluster analysis and the perceptual map of hierarchical clustering (Dendrogram) was obtained.

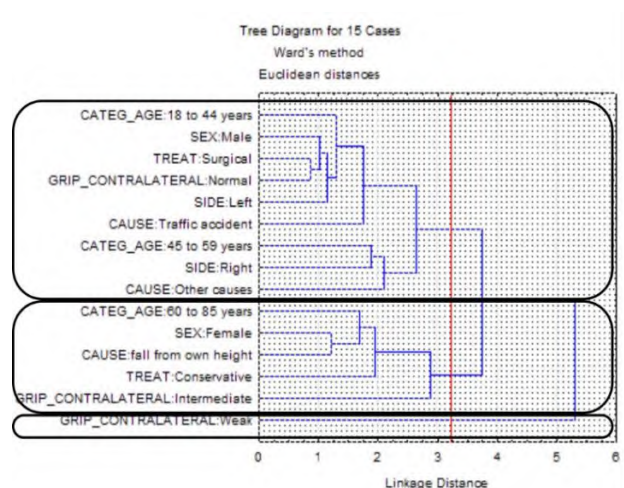
## RESULTS

One hundred and forty-one patients with distal radius fracture, who had grip strength measurements performed at 8-10 weeks after the fracture and followed the eligibility criteria, were included.

To characterize the profile of patients with distal radius fracture treated at a public hospital, a descriptive analysis was conducted. The total age average was 47 ( $\pm 17$ ) years, with men aging 40 ( $\pm 15$ ) years and women aging 55 ( $\pm 17$ ) years. When considering age groups, percentages for adults and the elderly were similar, with a slightly higher percentage of men compared to women.

Right dominance was predominant, and the fractures were more frequent in the left wrist. Regarding profession, the majority were blue collar workers (heavy manual workers). The most commonly employed treatment was surgical, using external fixation (EF). Grip strength was higher in men compared to women, both on the fracture side and on the contralateral side. When analyzing the gripping ratio between sexes, the values were similar (Table 1).

The dendrogram (Figure 1) from AHC performed through 15 coordinates was defined by the multiple correspondence analysis. The chosen criterion for defining the number of groups was the one of higher linkage distance and was represented by a red vertical arrow. Analyzing the fusion level behavior taking as a starting point the first higher distance, we chose to consider 3 groups, then this cluster analysis revealed three profiles of patients. One group included men, aged 18 to 59 years, with fractures either on the right or left side, trauma caused by traffic accidents or other causes, surgical treatment and normal grip strength on the contralateral side.



**Figure 1.** Agglomerative hierarchical clustering (AHC) dendrogram of dissimilarities and main cluster formations

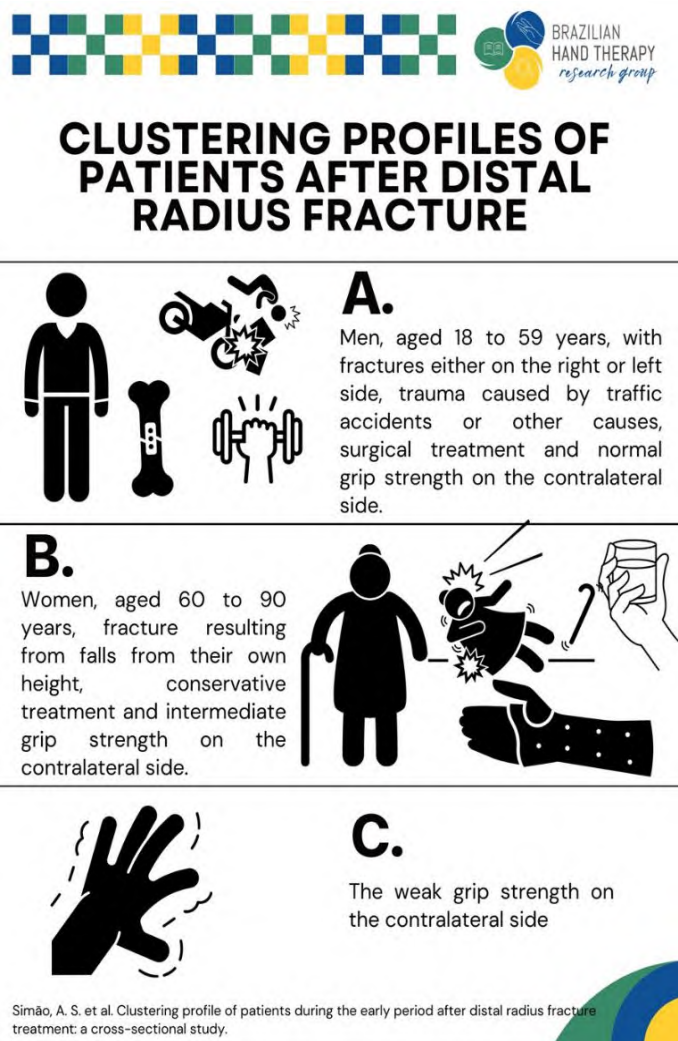
**Table 1.** Characterization patients' profile with distal radius fracture

Characteristics	Total (N= 141)
<b>Age group</b>	N (%)
18 to 44 years	62 (44.0%)
45 to 59 years	39 (27.7%)
60 to 90 years	40 (28.4%)
<b>Sex</b>	
Male	75 (53.2%)
Female	66 (46.8%)
<b>Hand dominance</b>	
Right side	131 (92.9%)
Left side	10 (7.1%)
<b>Profession</b>	
Housewife	18 (12.8%)
Blue collar workers (heavy manual work)	62 (44.0%)
White collar workers (office worker)	7 (5.0%)
Retired	10 (7.1%)
Student	5 (3.5%)
Others	32 (22.7%)
No information	7 (5%)
<b>Fracture side</b>	
Right	56 (39.7%)
Left	85 (60.3%)
<b>Cause of trauma</b>	
Fall from own height	50 (35.5%)
Traffic accident	49 (34.8%)
Other causes	42 (29.8%)
<b>Clinical treatment</b>	
Surgical	101 (71.6%)
Conservative	40 (28.4%)
<b>Type of treatment</b>	
Cast	40 (28.4%)
ORIF	24 (17.0%)
EF	44 (31.2%)
Pins	8 (5.7%)
Combination of treatments	25 (17.7%)
<b>Grip strength of fracture side (kgf)</b>	
Male	13.25 ( $\pm 7.36$ )
Female	7.62 ( $\pm 5.50$ )
<b>Grip strength of contralateral side (kgf)</b>	
Male	38.28 ( $\pm 8.90$ )
Female	23.35 ( $\pm 6.57$ )
<b>Gripping ratio*</b>	
Male	0.35 ( $\pm 0.18$ )
Female	0.32 ( $\pm 0.20$ )

ORIF= Open reduction internal fixation; EF= external fixation; Kgf= Kilogram force; \*Gripping ratio= grip strength of fracture side/Grip strength of contralateral side

The second group had women, aged 60 to 85 years, fracture resulting from falls from their own height, conservative treatment and intermediate grip strength on the contralateral side. The third

group had only the weak grip strength on the contralateral side. There was a predominant association according to sex and to demographic and clinical factors, and grip strength on the fracture contralateral side (Figure 2).



**Figure 2.** Clustering profiles of patients after distal radius fracture

## DISCUSSION

This study aimed to identify the profiles of patients after distal radius fracture treatment grouped according to demographic and clinical factors, and grip strength on the fracture contralateral side. Through cluster analysis, it was possible to identify two distinct profiles (2 groups), separated by sex, and a third group composed solely of weak grip strength, which was not grouped into either of the two main clusters.

Considering the descriptive analysis, we found that the majority of participants were men and 44% were aged 18 to 44 years. Regarding the cause of trauma, 35.5% of participants experienced falls from their own height, while 34.8% were involved in traffic accidents. The high incidence of distal radius fractures in male young adults and related to traffic accidents is attributed to the characteristics of the hospital where the study was conducted.

This hospital is highly specialized and deals with patients having more severe fractures, which also explains the high rate of surgical treatment at 71.6%. These results are consistent with what the literature describes: distal radius fracture as a typically

extra-articular fracture, most prevalent in women, and commonly resulting from a fall from one's own height with the hand in a flat position.<sup>2,22</sup> It is associated with reduced mineral density in post-menopausal women, and the commonly chosen treatment is conservative.<sup>23</sup>

However, the incidence of distal radius fractures has been increasing across all age groups,<sup>24</sup> including in male individuals. When it comes to men, sports and traffic accidents are known to be among the most common causes of distal radius fractures in young male adults.<sup>22</sup> A study on the patient profile following upper limb trauma was conducted at a public hospital, revealing a prevalence of 23.1% for distal radius fractures and 15.4% for radius and ulna fractures, among the total number of wrist and hand injuries resulting from motorcycle accidents. This underscores the growing incidence of distal radius fractures attributed to traffic accidents.<sup>25</sup>

Grip strength is directly associated with personal characteristics such as sex, age, hand dominance and weight.<sup>26</sup> The grip strength of men is significantly greater than that of women across all age groups, and in various nationality populations.<sup>15,27-29</sup> Regarding age, according to Puh,<sup>14</sup> grip strength begins to decrease as age increases. In our study the grip strength of men was greater than that of women; however, as 56% of the evaluated patients were aged over 44 years, the average grip strength was lower in both men and women in the Brazilian population.<sup>30</sup>

To measure palmar grip strength, the Jamar dynamometer was used, which is considered by some to be the gold standard among hand-grip dynamometers.<sup>31</sup> In this study, grip strength of the contralateral limb was categorized as normal, intermediate, and weak, with two of these categories grouped into the clusters. Thus, we can conclude that palmar grip strength is also a factor that differentiates patient profiles. Only the grip strength of the contralateral side was used because it was measured between the 8<sup>th</sup> and 10<sup>th</sup> weeks after the fracture, and during this early period, the palmar grip strength on the side of the fracture is greatly reduced.

In patients with distal radius fractures, palmar grip strength on the affected side remained lower (24.1 kgf) than on the contralateral side (31.1 kgf) after 1 year of treatment with the LCP volar plate in a sample of men and women, with an average age of 41 years. In our study, considering men and women, the handgrip strength on the side of the fracture was 10.6 kg and on the contralateral side it was 31.3 kgf.<sup>32</sup> We can observe that strength on the contralateral side was similar regardless of the fracture time, which can be considered a parameter to consider when grouping the profile.

The identification of patient profiles was carried out through Multiple Correspondence Analysis (MCA) followed by Agglomerative Hierarchical Cluster Analysis (AHC). In this type of analysis, we have the possibility of separating or classifying the categories of interest into groups or clusters in such a way that these groups have internal similarity and external discrepancy. Thus, it was possible to identify two distinct profiles (2 groups), separated by sex, and a third group solely with weak grip strength, which was not grouped into either of the two main clusters.

## Clinical relevance

Grip strengths below 16 kgf are classified as weak<sup>19</sup> for women, and in this study, the average force for women was 7.62 kgf. For men, a force less than 26 kgf is classified as weak,<sup>19</sup> and in our

study, the force was 13.25 kg. In both cases, grip strength in the initial phase of treatment was approximately 50% lower than the threshold considered weak. Individualized physiotherapeutic intervention strategies, including an early grip strength training program,<sup>33</sup> may be effective in promoting early and secure grip strength recovery. Therefore, programming an individualized treatment plan considering these determining factors may be a strategy for a faster recovery of grip strength, however, to verify the effectiveness of an individualized treatment plan must be realized in randomized clinical trials. The palmar grip strength on the contralateral side for women was also identified as intermediate, with values between 16 and 19 kg. The grip strength for men was classified as normal ( $\geq 32$  kg) according to the reference used, but according to Caporrino et al.<sup>30</sup> the average grip strength for Brazilian men varies from 42 to 45 kg. Therefore, an intervention involving the contralateral limb should be considered.

Data collection was conducted at a highly complex hospital specialized in assisting patients with more severe fractures resulting from high-energy traumas. Consequently, our sample had a higher number of cases of fractures in men, primarily due to traffic accidents, which are commonly treated surgically. This differs from what is typically found in the literature.

## CONCLUSION

Though cluster analysis performed according to demographic and clinical factors, and grip strength on the fracture contralateral side, it was possible to divide the patients in three different profiles. The first group included men, aged 18 to 59 years, with fractures either on the right or left side, trauma caused by traffic accidents or other causes, surgical treatment and normal grip strength on the contralateral side. The second group had women, aged 60 to 90 years, fracture resulting from falls from their own height, conservative treatment and intermediate grip strength on the contralateral side. The third group had only the weak grip strength on the contralateral side.

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