

Original Article

# Use of 3D printed orthosis and occupational therapeutic treatment in rhizarthrosis

## *Uso de órtese impressa em 3D e tratamento terapêutico ocupacional na rizartrorse*

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### Abstract

**Introduction:** Ligament laxity associated with mechanical stress on the trapeziometacarpal joint of the thumb is considered the main factor to predispose to rhizarthrosis. **Objective:** To evaluate the effect of using an orthosis made in a 3D printer associated with an occupational therapy rehabilitation program on pain, grip strength, and forceps of people with rhizarthrosis - stage I and II. **Method:** Case series study that used the instruments: Jamar<sup>®</sup> dynamometer, Preston Pinch Gauge, Visual Analog Pain Scale, and the Quebec User Evaluation of Satisfaction with Assistive Technology questionnaire. Participants underwent 14 Occupational Therapy sessions, twice a week and continued use of the orthosis. **Results:** 4 women and 2 men participated. They married (50%), complete higher education (50%), right-handed (83%) with a mean age of 54.3 (SD12.01). The results showed that the pain, measured by the VAS, improved for 5 (83.3%) participants since before the treatment the pain ranged from 3 to 10 and after from 0 to 6. The pulp forceps improved in 5 cases, the tripod clamp and handgrip improved in 4 cases and the lateral clamp improved in 2 cases. All users stated that they were satisfied with the orthosis and with the services offered and highlighted: “ease of use”, “monitoring services” and “comfort”. **Conclusion:** The use of orthosis made in a 3D printer associated with occupational therapy treatment proved to be effective in relieving pain, improving strength, and satisfying those affected by rhizarthrosis.

**Keywords:** Arthropathies, Orthopedic Devices, Occupational Therapy.

### Resumo

**Introdução:** A frouxidão ligamentar associada ao estresse mecânico sobre a articulação trapeziometacarpiana do polegar é considerada o principal fator para predispor a rizartrorse. **Objetivo:** Avaliar o efeito do uso de uma órtese confeccionada em

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impressora 3D associada a um programa de reabilitação terapêutico ocupacional sobre a dor, a força de preensão e pinça de pessoas com rizartrorse – estágio I e II. **Método:** Estudo de série de casos que utilizou os instrumentos: Dinamometro Jamar®, Preston Pinch Gauge, Escala Visual Analógica da Dor e o questionário Quebec *User Evaluation of Satisfaction with Assistive Technology*. Os participantes foram submetidos a 14 sessões de terapia ocupacional, 2 vezes por semana e ao uso contínuo da órtese. **Resultados:** Participaram 4 mulheres e 2 homens, casados (50%), escolaridade superior completo (50%), destros (83%), média de idade de 54,3 (DP12,01). Os resultados mostraram que a dor, medida pelo EVA, melhorou para 5 (83,3%) participantes, visto que antes do tratamento a dor variou de 3 a 10 e, após, de 0 a 6. A pinça polpa a polpa melhorou em 5 casos, a pinça tripode e a preensão palmar apresentou melhora em 4 casos e a pinça lateral melhorou em 2 casos. Todos os usuários afirmaram estar satisfeitos com a órtese e com os serviços oferecidos e destacaram: “facilidade de uso”, “serviços de acompanhamento” e “conforto”. **Conclusão:** O uso da órtese confeccionada em impressora 3D associada ao tratamento terapêutico ocupacional mostrou-se eficaz no alívio da dor, na melhora da força e na satisfação dos acometidos pela rizartrorse.

**Palavras-chave:** Artropatias, Aparelhos Ortopédicos, Terapia Ocupacional.

## 1 Introduction

Rhizarthrosis is a degenerative joint disease that affects the trapeziometarcarpian joint (TMC) of the thumb (Colditz & Koekebakker, 2010). Ligament laxity associated with mechanical stress and large loads exerted on the thumb joint is the main factor to predispose the disease (Egan & Brousseau, 2007).

In Brazil, rhizarthrosis affects 6 to 12% of adults in the population, with a higher incidence in postmenopausal women. People affected by this pathology report constant episodes of localized pain at the base of the thumb when moving it or holding loads in activities that involve the grasping and handling of objects (O'Brien & Giveans, 2013).

Eaton & Littler (1973) classified rhizarthrosis in four stages, according to the level of inflammation, the degree of joint wear, and the state of involvement of the subchondral bone. Stages I and II are eligible for conservative treatment with strong pain as the main characteristic. Stage I has a normal joint contour and the beginning of the decrease in the joint space of the TMC joint. On the other hand, stage II has a decrease in the joint space in the TMC joint with subchondral bone sclerosis.

Stages III and IV are eligible for surgical treatment since in stage III, there is a severe decrease in the joint space with cystic changes, bone sclerosis, dorsal dislocation, and the presence of osteophytes; and in stage IV there is additional impairment of the scaphoid trapezius joint (Egan & Brousseau, 2007). People affected by this clinical condition has constant episodes of pain located at the base of the thumb associated with loss of manual function during the activities of daily life (Weiss et al., 2000) such as writing, brushing their teeth, sewing, opening pots, turn taps or door handles and may require compensatory movements involving the wrist, elbow or other joints.

Occupational therapists are directly involved in the conservative treatment of rhizarthrosis through rehabilitation programs. Treatment sessions include therapeutic

activities/exercises and joint protection techniques, aimed to relieve pain, preserve the 1<sup>st</sup> interdigital space, maintain thumb movement, improve strength, and occupational performance (Cavalcanti, 2006). In the treatment process, the recommendation is to rest the painful and inflamed joint by an orthotic-orthosis device.

Orthoses are resources applied externally to a segment of the body to modify the structural or functional characteristics of the neuromusculoskeletal system. They can be used to immobilize, prevent or correct deformity, protect an injury, and assist the function (Assumpção, 2006) and provide stability during the performance of daily activities (Mertz, 2013).

There are different models of short orthosis for the thumb in the treatment of rhizarthrosis. They can be of dorsal or ventral use; however, there is no consensus in the literature of the best model for the treatment of rhizarthrosis. Souza (2006) writes that the selection of a particular design is intrinsically related to the individual and labor characteristics of each person.

Also, the development of personalized orthoses has a high cost due to the high price of the material, the techniques and molds used, often making its acquisition unfeasible for most less financially favored population. In a study developed with 52 occupational therapists from Brazil who worked with rheumatic patients, they sought to identify the barriers found for the use of orthosis in patients with thumb osteoarthritis (TO), and the results pointed to institutional policies as a barrier besides to absence and high cost of consumable material, especially low-temperature thermoplastic (Almeida et al., 2016).

Additive Manufacturing technology using the Material Fusion and Deposition (MFD) process, based on free software creations (Mertz, 2013) at a very low cost than traditional orthoses. Orthoses printed by Additive Manufacturing technology, also known as 3D printing, have advantages such as lightness, comfort, agility, and the possibility of being customized and modified according to the user through a modeled three-dimensional file.

Thus, this study aimed to evaluate the effect of using an orthosis made in a 3D printer associated with an occupational therapy rehabilitation program on pain and grip strength and forceps of people with stage I or II rhizarthrosis.

## **2 Method**

We carried out a case series study whose participants were people with clinical and radiological diagnosis of rhizarthrosis - stage I or II.

To select study participants, the following eligibility criteria were followed: clinical and radiological diagnosis in stage I or II of rhizarthrosis, present in the dominant hand or the non-dominant hand, over 18 years old, both genders, perception-cognitive ability to respond to the pain scale and perform the other tests of the study.

The study excluded individuals who underwent other rehabilitation treatments during the study period, associated pathologies (rheumatoid arthritis, diabetes, among others), hand surgery in the last six months, and/or changes in the use of pain medications in the last three months.

This research is part of an “umbrella” project entitled “Use of the 3D printer as a resource for the production of assistive technology devices - prostheses, orthoses, and adaptations - in the performance of occupational therapy”, approved by the Research Ethics Committee in Human Beings at the Federal University of Espírito Santo, under

protocol No. 2.101.139. All participants signed the Informed Consent Form (ICF) and were informed about the confidentiality of the information and the preservation of anonymity.

The sample participants were from the orthopedics clinic and the upper limb rehabilitation service of the State Hospital of Vila Velha, from the extension project Assistive Technology and Occupational Therapy for the Community - *TATO COMUNIDADE*, developed at the Federal University of Espírito Santo - UFES and the occupational therapy sector of the Physical Rehabilitation Center of Espírito Santo - *CREFES*.

In addition to the identification questionnaire containing: age, place of birth, gender, marital status, education, and profession, we used the following equipment and assessment instruments:

- Dinamometro Jamar®: Measurement of handgrip strength. This instrument contains a closed hydraulic system that measures the amount of strength produced by an isometric contraction applied to the handles, and the handgrip strength is recorded in kilograms or pounds (Figueiredo et al., 2007). We followed the recommendations of the American Society of Hand Therapists (1992). The participants were seated with the adducted shoulder, elbow flexed at 90°, forearm in a neutral position, and wrist between 0° and 30° of extension, and instructed to tighten the dynamometer as strong as they can, for three consecutive times, with a 2 to 3-minute rest between attempts. For calculating the handgrip strength, the final measure was the arithmetic mean between the three attempts (Figueiredo et al., 2007);
- Preston Pinch Gauge: Measurement of a lateral pinch, tripod, and pulp-pulp forceps. We also follow the standard recommended by the American Society of Hand Therapists (1992). For the three types of forceps, the participants made three attempts, with rest between each one of them to avoid fatigue, and then we calculated the average strength of the three consecutive measurements;
- Visual Analog Pain Scale (VAS): It evaluates the pain intensity. It has a straight line numbered from zero to ten, in which zero means no pain, and ten means the worst pain imaginable;
- QUEBEC - Quebec User Evaluation of Satisfaction with Assistive Technology - QUEST 2.0 (Demers et al., 2002). It evaluates the study participants' satisfaction with the orthosis and the services received. The test has 12 satisfaction items, from items 1 to 8 related to satisfaction with assistive technology, and from items 9 to 12, related to satisfaction with the services. Each of the items contains answers that are measured by the individual in the graduation from 1 (dissatisfied) to 5 (totally satisfied) (Carreira et al., 2010).

The consultations were carried out at the Functional Analysis and Technical Assistance Laboratory - *LAFATec* - UFES, of the Occupational Therapy Department. The participants eligible for the study had 12 interventional occupational therapy sessions (6 weeks), twice a week, with a minimum duration of 50 minutes, individually. The first and last sessions were aimed at evaluations, totaling 14 meetings.

In the first session, the identification we completed a questionnaire and evaluated the grip and clamp strength, and pain. The short orthosis mold was based on the model proposed by Butler & Svens (2005), which is placed on the back of the thumb, keeping

the metacarpophalangeal joint (MCP) between 35 to 40 degrees of flexion. We made a circle in the orthosis covering the MCP to allow its flexion (Sime et al., 2018).

The orthosis was printed at the 3D printing laboratory of the University Hospital Cassiano Antônio Moraes - Hucam - and molded on the participant after the second session of the intervention protocol, guided for its continuous use until the end of the treatment proposed by the research. We made necessary adjustments to the orthosis to avoid pressure points and maintain proper posture. Associated with this, the intervention consisted of therapeutic activities/exercises and joint protection techniques. In the last meeting, the same assessment instruments were used plus the satisfaction questionnaire - QUEST 2.0. Figure 1 shows the 3D printed orthosis.



**Figure 1 .** Orthosis for rhizarthrosis used in the research. Source: the authors.

The data were entered into a Microsoft Excel® 2010 spreadsheet and submitted to descriptive analysis and association between the variables of interest. For the presentation of sociodemographic and clinical data, the frequency was used for categorical variables and the mean and standard deviation for continuous variables. For analysis, we used the statistical program EPI INFO 7.2.

### 3 Results

Six people participated in the research with a confirmed diagnosis of rhizarthrosis - stage I or II.

Table 1 shows the social data.

**Table 1.** Distribution of the frequency of the social data of the research participants (N = 6).

SOCIAL DATA		N	%
GENDER	Female	4	66.7
	Male	2	33.3
AGE	30-39	1	16.7
	40-49	1	16.7
	50-59	1	16.7
	60-69	3	50.0
	Married	3	50.0
MARITAL STATUS	Widowed	1	16.7
	Divorced	1	16.7
	Single	1	16.7
	Elementary school	1	16.7
EDUCATION LEVEL	High school	2	33.3
	Higher education	3	50
	Dentist	2	33.3
OCCUPATION	Nursing technician	1	16.7
	Hairdresser	1	16.7
	Manicurist	1	16.7
	Elderly caregiver	1	16.7

Three (50.0%) of the 6 study participants had bilateral rhizarthrosis, 2 (33.3%) in the dominant hand, and 1 (16.7%) in the non-dominant hand.

Table 2 shows the dynamometry values.

**Table 2.** Dynamometry before and after the use of the orthosis and the occupational therapeutic rehabilitation program.

CASES/DOMINANCE/ COMMITMENT	BEFORE THE USE OF ORTHESIS AND REHABILITATION		AFTER USE ORTHESIS AND REHABILITATION		IMPROVEMENT / WORSE / MAINTENANCE
	RUL*	LUL*	RUL	LUL	
<b>PULP TO PULP CLAMP</b>					
<b>CASE 1</b>					
<b>Left</b>	<b>2.33</b>	3.4	<b>2.26</b>	3.5	Worse
<b>Right rhizarthrosis</b>					
<b>CASE 2</b>					
<b>Right</b>	<b>1.7</b>	2.13	<b>2.1</b>	2.26	improvement
<b>Right rhizarthrosis</b>					
<b>CASE 3</b>					
<b>Right</b>	<b>4.56</b>	<b>3.76</b>	<b>4.7</b>	<b>4.03</b>	

**Table 2.** Continued...

CASES/DOMINANCE/ COMMITMENT	BEFORE THE USE OF ORTHESIS AND REHABILITATION		AFTER USE ORTHESIS AND REHABILITATION		IMPROVEMENT / WORSE / MAINTENANCE
	RUL*	LUL*	RUL	LUL	
<b>PULP TO PULP CLAMP</b>					
<b>Bilateral Rhizarthrosis</b>					bilateral improvement
<b>CASE 4</b>					
<b>Right</b>	<b>3.53</b>	2.48	<b>4.83</b>	4.2	improvement
<b>Right rhizarthrosis</b>					
<b>CASE 5</b>					
<b>Right</b>	<b>1.93</b>	<b>1,3</b>	<b>2.6</b>	<b>2.93</b>	bilateral improvement
<b>Bilateral Rhizarthrosis</b>					
<b>CASE 6</b>					
<b>Right</b>	<b>2.53</b>	<b>2.9</b>	<b>3.76</b>	<b>3.33</b>	bilateral improvement
<b>Bilateral Rhizarthrosis</b>					
<b>TRIPOD CLAMP</b>					
<b>CASE 1</b>	<b>2.5</b>	2.26	<b>4.16</b>	4.5	improvement
<b>CASE 2</b>	<b>3.4</b>	3.4	<b>2.26</b>	2.16	Worse
<b>CASE 3</b>	<b>6.46</b>	<b>6.13</b>	<b>6.96</b>	7	bilateral improvement
<b>CASE 4</b>	<b>5.1</b>	3.9	<b>8.73</b>	7.33	improvement
<b>CASE 5</b>	<b>3.06</b>	<b>2.5</b>	<b>4.16</b>	<b>3.83</b>	bilateral improvement
<b>CASE 6</b>	<b>5.1</b>	<b>4.7</b>	<b>5</b>	<b>4.66</b>	bilateral worsening
<b>SIDE CLAMP</b>					
<b>CASE 1</b>	<b>4.9</b>	3.86	<b>4.43</b>	4.33	worse
<b>CASE 2</b>	<b>5.06</b>	4.7	<b>4.9</b>	5.2	Worse
<b>CASE 3</b>	<b>7.7</b>	<b>7.66</b>	<b>7.5</b>	<b>7.53</b>	bilateral worsening
<b>CASE 4</b>	<b>8.16</b>	7.4	<b>9.8</b>	7.8	improvement
<b>CASE 5</b>	<b>5.03</b>	<b>3.8</b>	<b>5.83</b>	<b>3.63</b>	Improvement on the right and worsening the left
<b>CASE 6</b>	<b>5.53</b>	<b>5.16</b>	<b>6.46</b>	<b>5.5</b>	bilateral improvement
<b>PALM HOLD</b>					
<b>CASE 1</b>	<b>17.96</b>	21.2	<b>23.33</b>	27.0	improvement
<b>CASE 2</b>	<b>17.0</b>	23.6	<b>23.66</b>	23.0	improvement
<b>CASE 3</b>	<b>22.7</b>	<b>22.03</b>	<b>29.0</b>	<b>29.0</b>	bilateral improvement
<b>CASE 4</b>	<b>32.33</b>	31.33	<b>39.66</b>	39.0	improvement
<b>CASE 5</b>	<b>19.66</b>	<b>15.66</b>	<b>17.0</b>	<b>12.0</b>	bilateral worsening
<b>CASE 6</b>	<b>18.66</b>	<b>22.16</b>	<b>18.33</b>	<b>17.33</b>	bilateral worsening

\*RUL- right upper limb; LUL- left upper limb.

Table 3 shows the pain intensity, measured by the visual analog scale before and after the occupational therapy treatment associated with the continuous use of the orthosis made

in a 3D printer. The results showed that the pain evaluated by VAS improved for 5 (83.3%) participants and in 1 (16.7%) case, it did not change after treatment.

**Table 3.** VAS - before and after the use of the orthosis and the occupational therapy rehabilitation program.

CASE	ANALOGIC VISUAL SCALE				IMPROVEMENT/ WORSE/MAINTENANCE
	BEFORE THE USE OF ORTHESIS AND REHABILITATION		AFTER THE USE OF ORTHESIS AND REHABILITATION		
	MSD*	MSE*	MSD	MSE	
CASE 1	3	-	0	-	improvement
CASE 2	9	-	1	-	improvement
CASE 3	3	1	1	0	bilateral improvement
CASE 4	3	-	1	-	improvement
CASE 5	10	10	5	2	bilateral improvement
CASE 6	6	7.5	6	7	maintain R and improve L

\*MSD- membro superior direito; MSE- membro superior esquerdo.

QUEST 2.0 investigated the participants' satisfaction with the orthosis and with the services offered. Table 4 shows the results obtained. The first section of the questionnaire contains 8 items that refer to satisfaction with the orthosis, whose results pointed out that “weight”, “ease of adjustment” and “ease of use” were the items that had a total score (30), that is, maximum score. The items “dimensions”, “stability and security” scored 26, indicating some dissatisfaction with these product characteristics. The three most chosen items in the equipment were: ease of use (66.67%), monitoring services (66.67%), and comfort (50%).

**Table 4.** Participants' satisfaction with the orthosis and with the services offered by analyzing the QUEST 2.0 questionnaire.

QUEBEC USER EVALUATION OF SATISFACTION WITH ASSISTIVE TECHNOLOGY						
ASSISTIVE TECHNOLOGY RESOURCE						
ITEMS	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Dimensions	4	4	3	5	5	5
Weight	5	5	5	5	5	5
Ease of adjustment	5	5	5	5	5	5
Stability and security	4	4	3	5	5	5
Durability	5	5	4	5	5	3
Ease of use	5	5	5	5	5	5
Comfort	5	5	4	4	5	4
SERVICES						
Delivery process	5	5	5	5	5	5
Repairs and technical assistance	5	4	5	5	5	5
Quality of services	5	5	5	5	5	5
Follow-up services	5	5	5	5	5	5

**Table 4.** Continued...

QUEBEC USER EVALUATION OF SATISFACTION WITH ASSISTIVE TECHNOLOGY						
ASSISTIVE TECHNOLOGY RESOURCE						
1. THREE MOST IMPORTANT ITEMS						
	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
<b>Item 1</b>	Ease of use	Safety	Ease of use	Dimension	Ease of use	Weight
<b>Item 2</b>	Comfort	Professional services	Comfort	Weight	Repairs/ technical assistance	Ease of use
<b>Item 3</b>	Services monitoring	Services monitoring	Efficiency	Comfort	Services monitoring	Services monitoring
<b>MOST CHOSEN ITEMS</b>	<b>1° Item</b>		<b>2° Item</b>		<b>3° Item</b>	
	Ease of use (66.67%)		Services monitoring (66.67%)		Comfort (50%)	
PUNCTUATION						
Items	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
<b>Invalid answers</b>	0	0	0	0	0	0
<b>Resources</b>	4.75	4.75	4.12	4.87	4.87	4.62
<b>Services</b>	5	4.75	5	5	5	5
<b>Total</b>	4.83	4.75	4.41	4.91	4.91	4.75
<b>Satisfaction</b>	Very satisfied	Very satisfied	Very satisfied	Very satisfied	Very satisfied	Very satisfied

In addition to the aforementioned assessments, we also carried out occupational therapeutic rehabilitation. The intervention included: thermotherapy/cryotherapy, massage, passive, active, and assisted active mobilization for maintenance/gain of range of movement of fingers and wrist, and a gradual muscle strengthening program using resources such as therapeutic mass, elastic band, exercisers fingers, halter, clay activity, among others. As for the general principles for joint protection, they were guided through a folder, made by the researchers, which contained a set of attitudes to be assumed by the patient, to save the joints from harmful and unnecessary loads.

#### 4 Discussion

This study shows the information on the effect of using an orthosis made in a 3D printer associated with an occupational therapy rehabilitation program on pain and grip strength and clamp of 6 people with stage I or II rhizarthrosis.

Four of the 6 participants were women and 2 were men, over 40 years old. These data are corroborated by several epidemiological studies, which demonstrated that rhizarthrosis is a common disease, sometimes bilateral, whose prevalence increases with age and predominantly affects the women in post-menopause (Carreira et al., 2010; Colditz & Koekebakker, 2010).

The professions of the participants were diverse, such as dentists, nursing technicians, hairdressers, manicurists, and elderly caregivers. Most of these activities involve movements that increase grip and pinch strength, causing mechanical stress and overload of small thumb joints, favoring the development of the disease (Egan & Brousseau, 2007).

Also, the daily activities of domestic services, culturally linked to the female gender, predominant in this sample, appeared as one more task performed by the participants of this study. Such activities suffered negative interference from the disease since even with difficulty, these women took care of the house, in a duel between pain and responsibility. The permanence of these tasks may have contributed to the speed of the damage caused by rhizarthrosis. In a study developed with patients in rheumatic conditions, Parreira et al. (2013) also found an unfavorable influence on the performance of occupational roles in domestic services among the research participants, due to the disease (Parreira et al., 2013).

In the pinch and handgrip forces, the results showed that the use of orthosis made in a 3D printer associated with occupational therapeutic intervention promoted an increase in the strength of the clamp pulp to a pulp in 5 cases, of tripod clamp and handgrip in 4 cases and lateral forceps in only 2 cases. Sousa et al. (2015) in their study found that the use of a short orthosis made of thermoplastic, associated with an occupational therapy rehabilitation program, led to a reduction in lateral pinch strength in women with rhizarthrosis - stage II. It corroborates with our findings that revealed that most of the evaluated cases did not show improvement in the lateral clamp.

Although the study by Bani et al. (2012) has evaluated only the effect of the short orthosis, without associating rehabilitation, on pain, function, grip strength, and clamp in 18 patients with trapeziometacarpal osteoarthritis of the thumb, their results corroborate this study in the grip strength and pulp to pulp clamp and tripod, since the use of the orthosis produced a decrease in pain and an increase in these strengths, added to the gain in the function of the hands and the strength of the lateral clamp.

In contrast to the previous study, Carreira et al. (2010) evaluated the efficacy of the short orthosis in forty patients diagnosed with rhizarthrosis and found that the use of orthosis during activities of daily living reduced the pain. However, it did not alter the function, grip strength, pinch strength, or dexterity in the research participants.

Several studies have investigated the effect of the use of orthosis for rhizarthrosis on clamp and grip strength (Weiss et al., 2000, 2004; Wajon & Ada, 2005; Egan & Brousseau, 2007; Valdes & Marik, 2010) with several procedures and very controversial results. We believe that these differences may be related to the selected orthotic models, in which the directions and ways of the strengths vary, as well as the use of orthosis associated with a rehabilitation program or not, gender, age group, and lateral dominance of the patient (Nicolay & Walker, 2005; Boustedt et al., 2009; Ferreira et al., 2011; Sousa et al., 2015).

Although the general set of researches is uncertain about the effect of the use of orthosis on strength and grip gain, in the case of rhizarthrosis, the orthotic resource is indicated to immobilize the involved joint, prevent deformities, and decrease the inflammatory process, favoring the restoration of function without pain (Colditz & Koekebakker, 2010). In this perspective, a study by Almeida et al. (2016), with 52 occupational therapists in Brazil, found that 94% of them indicate orthosis for the treatment of rhizarthrosis, which opts for made-to-measure models, with low-temperature thermoplastic as the most used material among the participants.

In our study, we chose the model that restricts the extension of the metacarpophalangeal joint of the thumb (MCP), printed in 3D with PLA material to measure in each participant. Some of the advantages of such orthosis molding are lightness, ease of adjustment, low cost, stabilization of the MCP joint and elimination of the

possibility of muscle atrophy due to disuse, and the non-impediment of the use of hands (Colditz & Koekebakker, 2010; Tanaka & Lightdale-Miric, 2016).

Research shows that, since 2001, assistive technology devices have been developed with the application of additive manufacturing in Brazil (Silva & Maia, 2014). Although the findings of this study were positive for pain relief and strength gain, in the orthoses, the literature lacks information that involves the use of this technology. Therefore, more scientific research, with larger samples, would be needed to determine whether 3D printed orthoses work better than those traditionally made in thermoplastic/neoprene. The development of new studies could also favor the development process of these devices, and seeking solutions for some problems found in current orthoses, such as imprecision, discomfort, and high cost.

Regarding the complaints reported by the participants, pain took a prominent place, responsible for reducing the manual function and negatively influencing the performance of daily activities. For people with rhizarthrosis, pain, and functional limitation, they are the main causes of seeking care.

Although the results in the literature are controversial as to the effects of the use of orthosis on pinch and grip strength, some studies suggest that the use of this resource is effective in reducing pain and improving manual function in people with rhizarthrosis (Carreira et al., 2010; Kjekken et al., 2011a; Sillem et al., 2011; Ye et al., 2011; Bani et al., 2012), corroborating this study. Sillem et al. (2011) compared three orthosis models, one prefabricated, one made to measure in Neoprene, and another in thermoplastic in patients with osteoarthritis in the carpometacarpal joint (CMC) of the thumb. The data showed a significant correlation between the use of the orthosis and a reduction in pain symptoms, as well as a slight improvement in hand functionality.

In a recent survey conducted by Meireles et al. (2019) investigating the efficacy of the orthosis for rhizarthrosis through a systematic review of fourteen studies, three of which participated in a meta-analysis, the results showed that the orthosis presented low-quality evidence for long-term pain reduction and moderate evidence of increased long-term function. However, the authors thought that the inaccuracy and inconsistency of the data were aspects that influenced the quality of the evidence and that future studies with larger samples and standardized data would be necessary.

In addition to the exclusive use of orthosis in the treatment of rhizarthrosis, Poole & Pellegrini Junior (2000) write that, in the early stages of this pathology, a specific exercise program together with the orthotic resource is beneficial in slowing the progression of the disease. Another approach to this issue comes from Kjekken et al. (2011b), who suggest that the use of orthosis associated with a daily exercise program can reduce pain, stiffness, and improve function. However, information on which exercises are most effective for osteoarthritis in the CMC thumb joint is still scarce (Kjekken et al., 2011b; O'Brien & Giveans, 2013).

Another important intervention in the treatment of rhizarthrosis to highlight is the education of the patient regarding joint protection. The person must understand how to prevent deformity positions and those that cause stress in the joints, especially in the thumb CMC. This is because, once this information is learned, the modification of daily activity will be more acceptable (Poole & Pellegrini Junior, 2000).

In this study, we carried out a combination of the 3 approaches mentioned above, such as joint protection guidelines, exercise/activity program, and 3D-made orthosis, which

were positive in improving pain and gaining strength among the participants. In the orthotic resource, it is important to consider the user's perception of the device and the factors that contribute to optimize its use and avoid abandonment.

In this perspective, we applied QUEST 2.0, in which the average score for the device session, the service, and the total average was high, indicating that all study participants were satisfied with the orthosis and with the services received. The three main characteristics mentioned in the orthosis made in 3D were: monitoring services, ease of use, and comfort. The last two items corroborate the findings of Joseph et al. (2018), in which comfort, efficiency, and ease of use were also the main characteristics of assistive technology (AT) resources used by the 72 participants in their research.

We conclude that the identification of the aspects desired by the user of the device can contribute to better adherence to treatment, to the therapist/patient bond, and to improving the prescription/preparation of the orthotic resource.

## 5 Conclusion

The reflections that guided the development of the study were focused on the investigation and analysis of the effect of the use of orthosis made on a 3D printer associated with a rehabilitation program on the pain and grip strength and forceps of people with stage I or II rhizarthrosis.

We conclude that the chosen treatment, use of 3D orthosis added to the intervention with therapeutic activities/exercises and joint protection techniques proved to be effective in relieving pain and in gaining grip strength and clamp for most participants.

Regarding QUEST 2.0, the results showed that all patients were satisfied with the equipment received, and with the service offered. In the 3D orthosis, the monitoring services and the ease of use and comfort were the three main characteristics of the device.

The 3D printing technique has been presented as an ally of the health sector and great value for assistive technology, despite its minimal use in the production of orthoses. In this sense, we expect that the study, for the time being, finalized, can contribute as an auxiliary instrument for the rehabilitation of people with rhizarthrosis, as well as being the starting point for the development of new research, because of the scarcity of works focusing on orthotic products. made with this technology.

Finally, the design of this work limits the generalization of the results since future studies with larger samples would be necessary to determine the effect of this 3D orthosis design on pain and grasping strength and forceps of people with rhizarthrosis.

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#### Author's contributions

Fabiana Drumond Marinho and Priscila Mendonça dos Santos were responsible for the development of research, design, and review of the article. Susilene Maria Tonelli Nardi, Mariana Midori Sime, and Gilma Corrêa Coutinho contributed to the design and review of the article. All authors approved the final version of the text.

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