Journal of Neurological Disorders

Cantero-Tellez, et al, J Neurol Disord 2016, 4:2
DOI: 10.4172/2329-6895.1000264

Research Article Open Access

Effects on Upper-Limb Function with Dynamic and Static Orthosis Use for Radial Nerve Injury: A Randomized Trial

Cantero-Téllez Raquel[1*], **Gómez-Martínez Miguel**[2] **and Labrador-Toribio Cristina**[2]

[1]*Faculty of Health Sciences, University of Malaga, C/ Arquitecto, Francisco Peñalosa, Spain*

[2]*Faculty of Health Sciences, Occupational Thinks Research Group, Centro Superior de Estudios Universitarios La Salle Madrid, Spain*

***Corresponding author:** Cantero-Téllez Raquel, Occupational Therapy Professor, Physical Therapy Department, Faculty of Health Sciences, University of Malaga, C/ Arquitecto Francisco Peñalosa, 29010, Spain, Tel: +34 952226453; E-mail: cantero@uma.es

Received date: February 10, 2016; **Accepted date:** April 13, 2016; **Published date:** April 15, 2016

Abstract

The management of radial nerve palsy associated with humerus's shaft fractures has been discussed for several decades, instead, is the most common nerve complication after humeral shaft fracture. Indeed, radial nerve palsy recovery rate ranges from 70 to 90%, many reports related to the use of dynamic orthosis options are described in the literature. The purpose of this study is to determinate which orthosis or splint is the best option to improve patient's upper limb function, measured with DASH (Disability arm shoulder and hand) questionnaire when surgical intervention is not indicated.

Final sample size consisted of 18 participants (14 men and 4 women) with an average age of 46 who suffered from a radial nerve lesion in the dominant arm after humerus's shaft fractures were included in the study. Participants were randomized into 2 equal groups (9 patients for the static orthosis or splint group and 9 for the dynamic orthosis/splint group).

The variance analysis showed a main effect in time lapse ($F (1, 58) = 71$, $P<0.001$) indicating a significant improvement in function. Results were significantly better for the static orthosis/splint group than for the dynamic splint group. Treatment with static orthosis produces further improvement in function compared to the treatment with dynamic orthosis.

Keywords: Radial Nerve; Orthoses; Static orthosis; Dynamic orthosis

Introduction

Radial nerve emerges from the posterior cord of the brachial plexus with the contribution of C5, C6, C7, C8, and T1 spinal nerve roots and then travels dorsal to the axillary artery and vein and closely abutting the shaft of the humerus near the spiral groove [1]. The radial nerve is a commonly injured upper extremity peripheral nerve; its superficial location in the spiral groove makes the nerve most vulnerable to an injury at a mid-humeral level. Common causes of radial nerve palsy are humeral fractures, elbow dislocations, and Monteggia fracture-dislocations [2,3]. The management of radial nerve palsy associated with of humerus's shaft fractures has been discussed for several decades, instead, is the most common nerve complication after humeral shaft fracture [3-5]. Most radial nerve injuries occur during trauma and they are still present when patient undertakes surgical intervention. Secondary nerve injuries may occur during patient preparation, exposed arm skin disinfection or during surgical procedure itself. Nerve can be entrapped between bone fragments or between the bone and plate [6].

Humeral fracture treatment together with radial nerve palsy remains controversial, especially for closed fracture for which there is no consensus. Indeed, radial nerve palsy recovery rate ranges from 70 to 90% [7,8]. As nerve first signs of recovery may emerge with delay, some authors do not advise performing an early procedure. Patient's evaluation for any signs of sensitivity and/or motor function recovery during 3 to 4 months after the humeral fracture reduction [9,10] It is recommended as a clinical intervention. Various literature studies have confirmed that delayed nerve surgery, including neurolysis or nerve grafting, can be useful in achieving satisfactory results in absence of radial nerve functional recovery after a middle-third humeral fracture.

Continuous wrist drop position creates tension through denervated extensor muscles causing them to elongate. Contrariwise innervated unopposed flexor muscles are slack or relaxed, causing them to shorten, resulting in a reduced joint mobility [11].

During power grip, extensor activation increases as flexor activity increases, therefore inability to extend wrist results in loss of tenodesis action and fingers use reduction for power grip and grasp-and-release actions [2], causing a hand function decreasement. Grip strength is created not only by forearm flexor activation, but also by simultaneous extensor activation as synergist [12].

During power grip, the wrist must be slightly extended for the extrinsic finger flexors to work maximally. Many researchers have reported that maximal grip strength was obtained in the range of 20-45° extension and it was reduced as the wrist was flexed [13,14]. Brand reported in 1974 [15] that for wrist to be stable in an optimal position during grasp, a balance between flexor and extensor muscles is needed. Because of this correlation between power grip and wrist extension we consider a very important fact, to reach an agreement for the most appropriate type of immobilization for these patients in order to help them to improve functionality during reinnervation time. They cannot perform their ADL (Activities of daily life) with wrist flexion due to the loose of grip power.

Literature supports that in most cases radial nerve is intact therefore a prognosis for complete recovery is expected. One of the challenges for hand therapists during this nerve regeneration period is to elaborate a splint that prevents over-stretching of denervated extensor musculature while maximizing hand function. Although splinting options are described in the literature, there is not enough evidence to support orthosis efficacy for improving hand function in patients with radial nerve palsy while awaiting nerve re-innervation stage.

There are many reports regarding use of dynamic extensor orthosis or splint during daytime and Wrist Cock-Up Splint advised to be worn at night-time. However, no previous investigation has stablished a correlation between the uses of these two different orthosis/splints during activities of daily living in order to improve function while waiting for a possible recovery [16].

The purpose of this study is to determinate which orthosis/splint is the best option to improve patient's upper limb function, measured with DASH (Disability arm shoulder and hand) questionnaire when surgical intervention is not indicated.

Methods

Participants

Data were collected at Tecan Hand Center clinic in cooperation with Málaga's University Hospital hand surgeons between June 2013 and December 2015. Ethics committee approved this research study and all patients handed over informed consent form. This study was performed in accordance with the Declaration of Helsinki.

The study's inclusion criteria were adults who suffered from a radial nerve lesion in the dominant arm after humerus's shaft fractures, diagnosed by a surgeon after surgery intervention using a minimally invasive plate osteosynthesis. All patients were included in the study after 3-5 weeks of surgical intervention.

The study's exclusion criteria were those patients with tendons associate injuries, other's nerves injuries, joint instability, wrist fracture or those unable to respond to the questionnaire. Final sample size consisted of 18 participants (14 men and 4 women) with an average age of 46 (SD 7, 4).

For information regarding the patient's own function perception, we used DASH Spanish Version, a self-administered questionnaire with 30 questions. The DASH is an outcome tool designed to measure physical function and symptoms in individuals with upper limb musculoskeletal disorders (MSDs).

Procedure

All participants were instructed to complete the DASH questionnaire before orthosis/splint was made in addition to a month later time questionnaire completion [17]. Participants (N=18) were registered into an Excel database in order of their arrival and were randomized into 2 equal groups done by a software program (9 patients in the static orthosis group and 9 in the dynamic orthosis group). Patients were instructed to wear splint during daytime and do not remove it during activities of daily living. Static volar orthosis supports the wrist and thumb in a functional position. Wrist was positioned at 30º of extension and thumb in opposition (Figure 1). Dynamic orthosis consisted of a static support for the wrist (across the palmar arch), whereas the fingers and thumb had dynamic extension assistance via cuffs around the proximal phalanges (Figure 2).

Static and dynamic orthosis were checked once a week for adjustments as necessary. Both groups follow up the same physical therapy treatment based on electrical stimulation, sensorial exercises, active exercises, proprioception and muscular control advice.

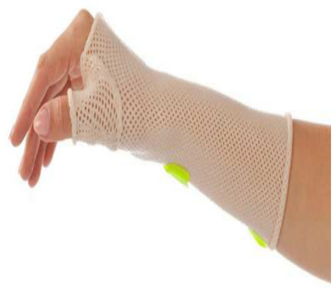

Figure 1: Static orthoses.

Figure 2: Dynamic orthoses.

Measurement outcomes

Spanish version of the DASH instrument (www.dash.iwh.on.ca) for measuring upper extremity disability was the measure outcome.

Data analysis

Means and 95% confidence interval were calculated to describe the sample size.

Changes in DASH questionnaire were analysed using variance analysis in intervention (Static and Dynamic orthosis) as the inter-subject variable, and intervals (pre-post) as the within-subject variable.

The level of significance was set at P less than .05.

When an interaction was found, inter-group effect size was calculated according to the Cohen d statistic [17].

	Static Orthosis Group Mean CI 95%	**Dynamic Orthosis Group Mean CI 95%**	**p Value**
Age (Years)	46.06 40.39 – 51.73	46.30 42.50 – 52.9	t = -0.071, p = 0.943

Table 1: Demographic data.

Results

Eighteen patients (4 women and 14 men) were included in the study. Participants demographic data are reported in Table 1. There were no significant age differences between groups. Regarding the DASH questionnaire, variance analysis showed a main effect in time lapse (F (1, 58) P<0.001) indicating a significant improvement in function for the second time interval measurement in both groups. Function improvement (DASH) between first and second assessment was significantly better for the static orthosis/splint group than for the dynamic splint group (Table 2). Treatment with static orthosis produces further improvement in function compared to the treatment with dynamic orthosis.

	Static Orthosis Group Mean (95%CI)	Dynamic Orthosis Group Mean (95%CI)
DASH (pre)	77,2 (66,7 to 81,60)	74,76 (62,50 to 79,9)
DASH (post)	52,42 (40,60 to 66,70)	60,88 (50,40 to 66,80)

Table 2: Pre and post treatment for DASH outcomes.

Discussion

The inability to extend and stabilized the wrist causes the patient to be unable to used his long flexors adequately. Splinting is an intervention used frequently by hand therapists to treat patients with radial nerve palsy in order to preserve movement and prevent overstretching of the denervated muscles. The importance of demonstrating treatment effectiveness in different interventions is acknowledged and accepted by clinicians [2,18-21]. Although it is necessary to continue with research about the effectiveness on static and dynamic orthosis function, these preliminary findings suggest that static orthoses including thumb, although does no replace the fine manipulative ability of the hand, may be a feasible alternative for gross motor function improvement after radial nerve injury taking into consideration patient self reports appreciation.

We often refer to published literature on research evidence to support our treatment choices in those cases with more appropriated orthosis use in order to improve function during the nerve regeneration. Although radial nerve is a commonly injured peripheral nerve, no randomized controlled trial has found what orthosis is most appropriate to enhance hand use and manual function in these patients.

Several orthosis have been outlined as an extension aid for patients with radial nerve trauma and they are used as temporary orthosis to enhance function while nerve regeneration occurs or until tendon transfers are performed to restore wrist and digital extension.

Previous studies where dynamic orthosis have been used indicate adverse neural tension prevention throughout the used of splints with a dynamic traction component [18,19], and describes the thumb section as the most important aspect to improve function [19]. This is the reason why we have used a static orthosis including thumb as well as a dynamic one. There are some studies describing different orthosis designs after radial nerve injury, but few results compare the effect on function from two or more designs.

The orthosis originally described by Crochetiere et al. [20] and later modified by Hollis [21] and Colditz [2] uses static thread instead of dynamic rubber bands to suspend proximal phalanges. These splints are effective in recreating tenodesis effect for the digits to allow flexion and extension, but do not include an outrigger to allow thumb extension and abduction. As opposition, is the most important hand functional movement [22], we have modified the orthosis in our study to include thumb.

According to Callinan [23] and Yuen Yee Chan [24], a daytime use of an orthoses that restricts wrist mobility promotes compensatory shoulder elevation that can cause harmful muscle pain and fatigue and imposes undue functional hindrance. In both cases, we have immobilized wrist in light extension. Although shoulder pain has not been measured as a variable in the present study, previous studies show that there is a positive correlation between pain and function measure with DASH questionnaire [22,25-27]. Therefore, according to our results, we could expect that static orthosis with thumb inclusion should be better to prevent compensatory shoulder elevation based on DASH questionnaire results, but specific studies should be conducted in the future to determine the effect of wrist immobilization after radial nerve injury on shoulder movements.

Susan D. Hannah et al. [28] conducted a single subject research to compare the patient's responses to four treatments interventions-no splint, static volar wrist, cock-up splint, dynamic tenodesis suspension splint, and dorsal wrist cock-up with dynamic finger extension splint. A reduction in score on DASH in all groups reflects, as our study, that uses of orthosis improve patient's upper extremity disability and symptoms. Comparing the effects of different orthosis, they concluded that hand function improved with both dynamic splints: even more the dorsal wrist cockup with dynamic finger extension splint than the dynamic tenodesis suspension splint. However, patient preferred a static volar wrist cock-up splint because it offered support, was easy to put on, and was less visible to wear than the other two splints. Ease of use may be the cause for which our patients refer a function improvement when using static orthosis more than a dynamic one. As our clinical goal is to design an orthosis that improves function where patient is also willing to wear, it is necessary to consider patient satisfaction in order to choose the best option. In addition, we must take into consideration other variables as the patient activity or occupation, sex and level of muscle fatigue.

Despite using a functional specified upper limb scale as a outcome measure, we did not use another questionnaire to compare the results and it could be a limitation of our study as no reliable data on the specificity of DASH questionnaire in radial paralysis have been describe previously.

We must consider future research to compare one orthosis designs with others in order to define the best device, not only for nerve resolution but also for patient satisfaction. In order to do so we will have to take into consideration different variables as age, sex, occupation, dominant hand and level of injury.

References

1. Secer HI, Solmaz I, Anik I, Izci Y, Duz B, et al. (2009) Surgical outcomes of the brachial plexus lesions caused by gunshot wounds in adults. J Brachial Plex Peripher Nerve Inj 4: 11.
2. Colditz JE (1987) Splinting for radial nerve palsy. J Hand Ther 1:18-23.
3. DeFranco MJ, Lawton JN (2006) Radial nerve injuries associated with humeral fractures. J Hand Surg Am 31: 655-663.
4. Jawa A, Jupiter J (2009) Fracture-associated nerve dysfunction. J Hand Surg Am 34: 924-927.
5. Cognet JM, Fabre T, Durandeau A (2002) Persistent radial palsy after humeral diaphyseal fracture: cause, treatment, and results. 30 operated cases. Rev Chir Orthop Reparatrice Appar Mot 88: 655-662.
6. Bichsel U, Nyffeler R (2015) Secondary radial nerve palsy after minimally invasive plate osteosynthesis of a distal humeral shaft fracture. Case Reports in Orthopedics. Sept Volume 2015.
7. Shao YC, Harwood P, Grotz MR, Limb D, Giannoudis PV (2005) Radial nerve palsy associated with fractures of the shaft of the humerus: a systematic review. J Bone Joint Surg Br 87: 1647-1652.
8. Ekholm R, Ponzer S, Törnkvist H, Adami J, Tidermark J (2008) Primary radial nerve palsy in patients with acute humeral shaft fractures. J Orthop Trauma 22: 408-414.
9. Shah A, Jebson PJ (2008) Current treatment of radial nerve palsy following fracture of the humeral shaft. J Hand Surg Am 33: 1433-1434.
10. Verga M, Peri Di Caprio A, Bocchiotti MA, Battistella F, Bruschi S, et al. (2007) Delayed treatment of persistent radial nerve paralysis associated with fractures of the middle third of humerus: review and evaluation of the long-term results of 52 cases. J Hand Surg Eur Vol 32: 529-533.
11. Brand PW (1995) Mechanical factors in joint stiffness and tissue growth. J Hand Ther 8: 91-96.
12. Shimose R, Matsunaga A, Muro M (2011) Effect of submaximal isometric wrist extension training on grip strength. Eur J Appl Physiol 111: 557-565.
13. Claudon L (2003) Relevance of the EMG/grip relationship in isometric anisotonic conditions. Int J Occup Saf Ergon 9: 121-134.
14. Li ZM (2002) The influence of wrist position on individual finger forces during forceful grip. J Hand Surg Am 27: 886-896.
15. Brand PW (1974) Biomechanics of tendon transfer. Orthop Clin North Am 5: 205-230.
16. Dellon AL (2000) Somatosensory testing and rehabilitation. Baltimore: Institute for Peripheral Nerve Surgery.
17. Rosales RS, Delgado EB, Díez de la Lastra-Bosch I (2002) Evaluation of the Spanish version of the DASH and carpal tunnel syndrome health related quality-of-life instruments: Cross cultural adaptation process and reliability. J Hand Surg Am 27: 334-343.
18. McKee P, Nguyen C (2007) Customized dynamic splinting: Orthoses that promote optimal function and recovery after radial nerve injury: A Case Report. J Hand Ther 20:73-88.
19. Van Lede P (2003) Discussion regarding tension adjusters for dynamic splints, personal communication.
20. Crochetiere W, Granger CV, Ireland J (1957) The B Granger orthosis for radial nerve palsy. Orthop Pros 29: 27.
21. Hollis I (1978) Innovative splinting ideas. In: Hunter Jea, (ed.) Rehabilitation of the Hand. St. Louis: Mosby.
22. Cantero-Téllez R, Martín-Valero R, Cuesta-Vargas A (2015) Effect of muscle strength and pain on hand function in patients with trapezio metacarpal osteoarthritis. A cross-sectional study. Reumatol Clin 11: 340-344.
23. Callinan N (1999) Clinical interpretation of "an electromyography study of wrist extension orthoses and upper-extremity function. Am J Occup Ther 53: 441-444.
24. Yuen Yee Chan W, Chapparo C (1999) Effect of wrist immobilization on upper limb function of elderly males. Technol Disabil 11: 39-49.
25. Cantero-Téllez R, Cuesta-Vargas AI, Cuadros-Romero M (2015) Treatment of proximal interphalangeal joint flexion contracture: combined static and dynamic orthotic intervention compared with other therapy intervention: a randomized controlled trial. J Hand Surg Am 40: 951-955.
26. Boustedt C, Nordenskiöld U, Lundgren Nilsson A (2009) Effects of a hand joint protection programme with an addition of splinting and exercise: one year follow-up. Clin Rheumatol 28: 793-799.
27. MacDermid JC, Wessel J, MacIntyre N, Galea V (2008) The relationship between impairment, dexterity and self-reported disability of persons with osteoarthritis of the hand. J Hand Ther 21: 423-424.
28. Hannah SD, Hudak PL (2001) Splinting and radial nerve palsy: a single-subject experiment. J Hand Ther 14: 195-201.