J Shoulder Elbow Surg (2015) ■, 1-6

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

Arthroscopic rotator cuff repair in the weight-bearing shoulder

Jacek Kerr, MD[a], Paul Borbas, MD[b], Dominik C. Meyer, MD[b], Christian Gerber, MD, FRCSEd(Hon)[b], Carlos Buitrago Téllez, MD[c], Karl Wieser, MD[b,*]

[a]*Swiss Paraplegic Centre Nottwil, Nottwil, Switzerland*
[b]*Department of Orthopaedics, Balgrist University Hospital, University of Zürich, Zürich, Switzerland*
[c]*Institute of Radiology, Zofingen Hospital, Zofingen, Switzerland*

Background: In wheelchair-dependent individuals, pain often develops because of rotator cuff tendon failure and/or osteoarthritis of the glenohumeral joint. The purposes of this study were to investigate (1) specific rotator cuff tear patterns, (2) structural healing, and (3) clinical outcomes after arthroscopic rotator cuff repair in a cohort of wheelchair-dependent patients.

Methods: Forty-six shoulders with a mean follow-up of 46 months (range, 24-82 months; SD, 13 months) from a consecutive series of 61 shoulders in 56 patients (46 men and 10 women) undergoing arthroscopic rotator cuff repair were available for analysis. Clinical outcome analysis was performed using the Constant-Murley score, the Subjective Shoulder Value, and the American Shoulder and Elbow Surgeons score. The integrity of the repair was analyzed by ultrasound.

Results: Of the shoulders, 87% had supraspinatus involvement, 70% had subscapularis involvement, and 57% had an anterosuperior lesion involving both the supraspinatus and subscapularis. Despite an overall structural failure rate of 33%, the patients showed improvements in the Constant-Murley score from 50 points (range, 22-86 points; SD, 16 points) preoperatively to 80 points (range, 40-98 points; SD, 12 points) postoperatively and in the American Shoulder and Elbow Surgeons score from 56 points (range, 20-92 points; SD, 20 points) preoperatively to 92 points (range, 53-100 points; SD, 10 points) postoperatively, with a mean postoperative Subjective Shoulder Value of 84% (range, 25%-100%; SD, 17%).

Conclusion: Failure of the rotator cuff in weight-bearing shoulders occurs primarily anterosuperiorly. Arthroscopic rotator cuff repair leads to a structural failure rate of 33% but satisfactory functional results with high patient satisfaction at midterm follow-up.

Level of evidence: Level IV, Case Series, Treatment Study.

Keywords: Arthroscopic rotator cuff repair; weight-bearing shoulder; wheelchair; shoulder; rotator cuff; subscapularis; supraspinatus

The responsible institutional review board (Kantonale Ethikkommission Luzern) approved the study. Written consent was obtained from all patients willing to attend a follow-up visit. For those who did not provide written consent, on the basis of a general permit issued by the responsible state agency, our institutional review board allows retrospective analysis of patient data relating to standard diagnostic or therapeutic procedures without individual informed consent.

*Reprint requests: Karl Wieser, MD, Department of Orthopaedics, Balgrist University Hospital, University of Zürich, Forchstrasse 340, CH-8008 Zürich, Switzerland.

E-mail address: karl.wieser@balgrist.ch (K. Wieser).

1058-2746/$ - see front matter © 2015 Journal of Shoulder and Elbow Surgery Board of Trustees.
http://dx.doi.org/10.1016/j.jse.2015.05.051

Pain and/or overuse injuries of the upper extremities will develop in up to 62% of wheelchair-dependent individuals.[7] Because of intensive use of the upper extremities during transfer, torso stabilization, and wheelchair propulsion, the term ''weight-bearing shoulder'' has been established.

A 3-dimensional model has identified active wheelchair propulsion to impose a significant upward force at the shoulder,[13] and the absence of trunk innervation further increases the biomechanical stresses on the upper extremities during functional activities.[10] Wheelchair dependence also requires frequent, prolonged, and repetitive overhead reaching to access the environment from a sitting position. The overhead requirements of daily living have received little attention; recent studies, however, have shown that load during overhead movements in wheelchair users was higher than for mere wheelchair propulsion.[18] The daily living activities in wheelchair-dependent individuals involve continuous and repetitive use (overuse) of their rotator cuff muscles, and it seems reasonable to assume that structural changes of the shoulder joint are more frequent, more severe, and probably more disabling in individuals with longstanding paraplegia. The reported prevalence of rotator cuff lesions in the weight-bearing shoulder was 63% after a mean of 33.7 years of wheelchair dependency in a population with a mean age of 52 years,[1] and overall, up to 65% to 73% of wheelchair users with pain have rotator cuff tears.[2,6] Seventy-five percent of these tears were considered chronic or degenerative,[2] and etiologically, such tears are more closely related to wear and tear rather than aging.[1]

Despite these high numbers of disabling shoulder pain in wheelchair-dependent patients, there is a paucity of data available to help clinicians to decide how to treat such a problem in these high-demand patients.[8,12,16,17] The purposes of this study were therefore to investigate (1) specific rotator cuff tear patterns, (2) structural healing, (3) and clinical outcomes of arthroscopic repair in wheelchair-dependent patients.

Materials and methods

This is a retrospective case series of arthroscopic rotator cuff repairs in wheelchair-bound patients. All patients who were wheelchair dependent preoperatively and postoperatively and underwent arthroscopic repair of a full-thickness rotator cuff lesion in a dedicated unit for the study of paraplegia between 2006 and 2011 were identified from a prospectively collected institutional database and constituted the study cohort. There were 61 operated shoulders in 56 patients (46 men and 10 women) with a minimum follow-up of 24 months. The patients had a mean age of 55 years (range, 27-89 years; SD, 11 years) and had been wheelchair dependent for a mean of 23 years (range, 0.3-56 years; SD, 14 years) before surgery. The reasons for wheelchair dependence were mainly traumatic spinal cord injuries (Table I) at the thoracic level (Fig. 1).

The aforementioned patients were invited to undergo a study-specific follow-up analysis (Fig. 2). Of the 15 patients (27%) who were not available for study-specific follow-up, 6 had a previously documented retear (2 traumatic) with revision surgery after a mean of 12 months (range, 2-26 months). Of the other 9 patients, 6 were living abroad, 2 were living in a nursing home (advanced dementia), and 1 refused to attend the follow-up visit. The remaining 46 shoulders could be personally examined after a mean follow-up of 46 months (range, 24-82 months; SD, 13 months). For 37 of these 46 shoulders, the preoperative Constant-Murley score (CS) and American Shoulder and Elbow Surgeons (ASES) score on the standardized form for shoulder assessment, as well as magnetic resonance arthrography, were available for retrospective analysis; preoperative magnetic resonance imaging (MRI) was not available for 5 shoulders, and the preoperative CS or ASES score was not available for 4.

Table I Reasons for wheelchair dependence

Reason	n
Spinal cord injury	44
Poliomyelitis	3
Tumor	2
Ischemic	2
Amputation	1
Spina bifida	1
Iatrogenic after spinal anesthesia	1
Syringomyelia	1
Cerebral palsy	1

Clinical outcome analysis was performed by 2 investigators (K.W. and P.B.) different from the single surgeon who had carried out all the procedures. The CS (which ranges from 0 to 100 points, with 100 points being the best score), the Subjective Shoulder Value (SSV) (which ranges from 0% to 100%, with 100% being the best score), and the ASES score on the standardized form for shoulder assessment (which ranges from 0 to 100 points, with 100 points being the best score) were used. Patients were further asked to categorize their subjective outcome and satisfaction with the surgical result as poor, fair, good, or very good.

The integrity of the repair was analyzed by ultrasound performed by an experienced and independent radiologist (C.B.T.) with special training in musculoskeletal radiology. Every tendon of the rotator cuff was examined and categorized as (1) being intact, (2) having a partial articular- or bursal-sided lesion, or (3) having a full-thickness lesion.

Surgical technique and postoperative care

The first author (J.K.) performed all procedures arthroscopically with the patient in the beach-chair position under general hypotensive anesthesia. The number of fixation points for screw-in anchors was determined according to tear size and tendon retraction. In case of supraspinatus (SSP) and infraspinatus (ISP) involvement with increased tension on the repair, an abduction splint was worn for 6 weeks postoperatively (n = 14). Otherwise, the shoulders were protected using a sling (n = 47). All patients were hospitalized for about 10 weeks in a center for paraplegic patients, focusing on holistic rehabilitation and comprehensive care for wheelchair-dependent patients. The postoperative rehabilitation protocol included use of an electronic wheelchair and strictly passive exercises under the supervision of a physical

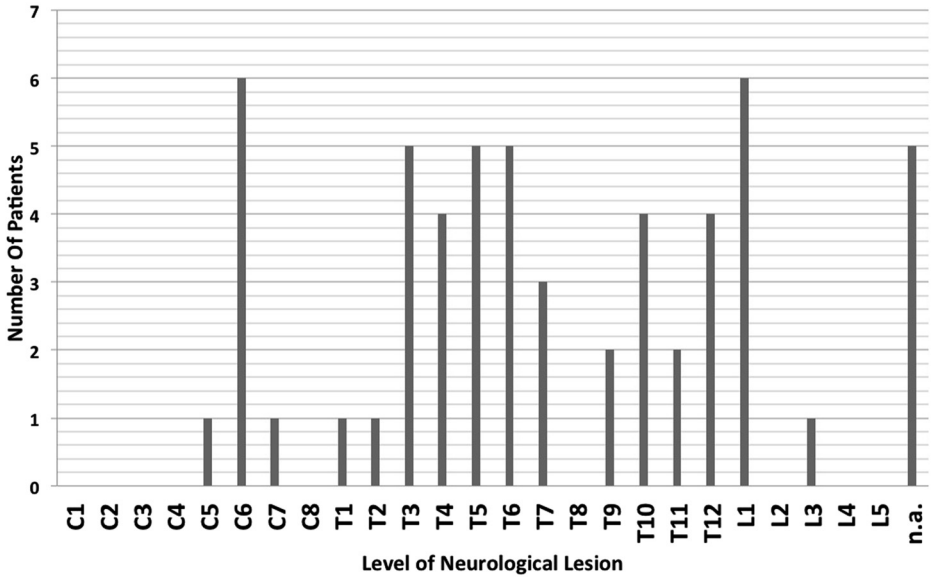

Figure 1 Level of neurologic lesions. n.a., not applicable.

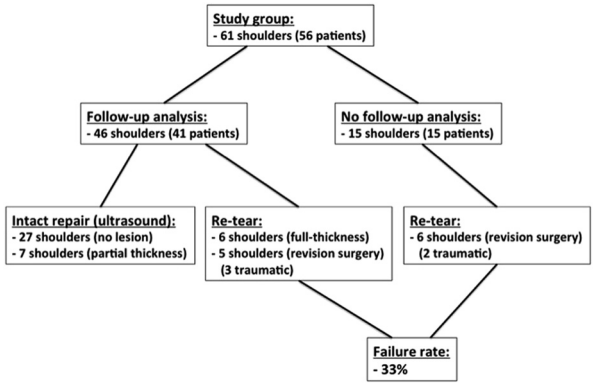

Figure 2 Flowchart.

therapist during the first 6 weeks. After 6 weeks, limited indoor manual wheelchair use was allowed, beginning with 1 to 2 hours per day, without upward or downward inclination, slowly increasing the duration and speed over time, alternating with electronic wheelchair use. A supervised active exercise program started after 6 weeks, with strengthening exercises beginning after 12 weeks. Transfer training was started after 8 weeks invariably with the use of a transfer board until 4 months postoperatively. Further patient instructions included limited use of high transfers, adjustment of bed height, and additional car modifications (ie, for wheelchair loading and unloading). Furthermore, muscle-strengthening physiotherapy was continued if possible twice a week during the first postoperative year.

Statistical analysis

Descriptive statistical methods were used to report the data, with mean, range (minimum to maximum), and standard deviation. Comparisons of preoperative and postoperative scores were performed with the use of the Wilcoxon signed rank test. $P < .05$ was considered significant. All statistical analyses were performed using IBM SPSS Statistics software (version 20.0; IBM, Armonk, NY, USA).

Results

Of the 61 operated shoulders, 25% (n = 15) had a single-tendon lesion, 52% (n = 32) had involvement of 2 tendons, and 23% (n = 14) had involvement of 3 tendons. Regarding repair type, 22 shoulders (36%) underwent combined subscapularis (SSC) and SSP repair; 14 (23%) underwent combined SSC, SSP, and ISP repair; 10 (16%) underwent combined SSP and ISP repair; 8 (13%) underwent isolated SSC repair; and the remaining 7 (11%) underwent isolated SSP repair. Therefore, 87% of the shoulders had SSP involvement, 70% had SSC involvement, and 57% had an anterosuperior lesion involving the SSC and SSP (with or without ISP involvement). Of the 61 shoulders, 51 underwent additional biceps tenotomy and tenodesis because of tendinopathy, a partial tear, or pulley instability. The mean preoperative Goutallier stages, as shown on MRI, were as follows: stage 1.4 (range, 0-3; SD, 1.3) for the SSC, stage 1.1 (range, 0-3; SD, 1.0) for the SSP, stage 0.7 (range, 0-3; SD, 0.9) for the ISP, and stage 0.1 (range, 0-1; SD, 0.2) for the teres minor.

A documented retear leading to revision surgery was found in 5 of the 46 shoulders (11%) that could be analyzed after a mean follow-up of 46 months (range, 24-82 months). Of the remaining 41 shoulders without revision surgery, 6 (15%) showed a full-thickness tear at least 1 of the repaired rotator cuff tendons (4 SSP, 1 SSC, and 1 combined SSP/ESP). In 7 shoulders (17%), we found a partial-thickness lesion (all

articular sided; 5 SSP, 1 SSC, and 1 both), whereas 27 shoulders (66%) showed an intact rotator cuff repair without a partial- or full-thickness tear on the ultrasonographic control images. Considering partial-thickness lesions as intact repairs,[4] we found a structural failure rate (revision or full-thickness tear) of 24% (11 of 46 shoulders). This group had a mean age of 53 years (range, 42-63 years) and mean preoperative Goutallier stages of 1.7 for the SSC, 0.8 for the SSP, and 0.8 for the ISP, as compared with a mean age of 54 years (range, 30-68 years) and mean Goutallier stages of 1.4 for the SSC, 0.9 for the SSP, and 0.5 for the ISP in the group with intact repairs. With the inclusion of the 6 patients who had a documented retear with revision surgery but did not present for the study-specific follow-up examination, the overall failure rate increases to 33% (17 of 52 shoulders). Of these 17 patients, 5 had a clear traumatic event leading to either early diagnosis of a retear or revision surgery (or both).

In the 46 shoulders, the mean CS improved from 50 points (range, 22-86 points; SD, 16 points) preoperatively to 80 points (range, 40-98 points; SD, 12 points) postoperatively and the mean ASES score improved from 56 points (range, 20-92 points; SD, 20 points) preoperatively to 92 points (range, 53-100 points; SD, 10 points) postoperatively (4 patients did not have preoperative scores available). The mean postoperative SSV was 84% (range, 25%-100%; SD, 17%). The subjective results were poor in 0 shoulders, fair in 3, good in 11, and very good in 32 (97% good and very good).

The 35 shoulders without evidence of a retear or revision had a mean CS of 51 points (range, 22-86 points; SD, 16 points) and mean ASES score of 55 points (range, 20-92 points; SD, 21 points) preoperatively (2 patients did not have preoperative scores available); the mean CS increased to 82 points (range, 40-98 points; SD, 11 points) and the mean ASES score increased to 94 points (range, 53-100 points; SD, 9 points) postoperatively, with an SSV of 86% (range, 25%-100%; SD, 17%). Regarding patient satisfaction, there were 0 poor, 1 fair, 7 good, and 27 very good results (97% good and very good).

In the patients who had a retear at final follow-up (n = 6, of which 1 was traumatic), the mean CS increased from 46 points (range, 35-63 points; SD, 15 points) to 74 points (range, 51-89 points; SD, 14 points) and the mean ASES score increased from 58 points (range, 47-75 points; SD, 15 points) to 87 points (range, 70-98 points; SD, 12 points) (2 patients did not have preoperative scores available), with an SSV of 73% (range, 50%-90%; SD, 17%). There were 0 poor results, 1 fair result, and still 2 good and 3 very good results (83% good and very good).

These results were barely different from those of patients who underwent revision (2 because of traumatic incidences) and had ultrasonographic evidence of a healed re-repair (n = 5), in whom the mean CS improved from 45 points (range, 25-63 points; SD, 16 points) to 71 points (range, 48-91 points; SD, 17 points) and the mean ASES score improved from 55 points (range, 42-78 points; SD, 15 points) to 81 points (range, 70-98 points; SD, 12 points), with an SSV of 82% (range, 50%-100%; SD, 20%). There were 0 poor, 1 fair, 2 good, and 2 very good results (80% good and very good).

Discussion

The most important findings of this investigation were as follows: (1) There is a specific rotator cuff tear pattern in weight-bearing shoulders, with most tears involving the anterosuperior cuff with the SSP (87%) or SSP and SSC (57%) tendons; (2) the structural failure rate of arthroscopic rotator cuff repair is 33%; and (3) 93% of patients (with or without retear or revision) rate their results as good or very good. In contrast to able-bodied patients, our series of patients underwent an intensive and prolonged postoperative rehabilitation period, with an approximately 10-week hospital stay in a highly specialized unit. This resulted in a very standardized and controlled rehabilitation protocol, which may have contributed to the favorable results in these usually highly motivated but demanding patients.

We are aware of the potential limitations of this investigation. Given the retrospective study design, we can exclude a selection bias because patients were identified from a prospective patient database and were included in the study if they met the inclusion criteria (arthroscopic repair of full-thickness rotator cuff lesion and preoperative and postoperative wheelchair dependence). However, 15 patients (27%) were not available for study-specific follow-up analysis. Although 6 patients with known retears and revision surgery were included in the failure analysis, there were still 9 patients without study-specific clinical and radiographic outcome analyses; however, especially for patients living abroad, wheelchair dependence is a major factor compromising personal review for scientific purposes. Postoperative radiologic evaluation using ultrasound might be considered a limitation of this study. However, given the difficulties in obtaining MRI studies for those additionally impaired patients and the possibility of assessing the integrity of the rotator cuff repair dynamically, we decided to use this modality. Furthermore, it has recently been shown that there was 92% agreement between MRI and ultrasound readings in the setting of postoperative evaluation of cuff repairs.[4] Moreover, we can exclude an assessment bias because 2 independent orthopaedic surgeons (K.W. and P.B.) and 1 independent radiologist (C.B.T.), all of whom were involved in neither surgical treatment nor preoperative or postoperative care, examined all patients and analyzed the data.

Despite the aforementioned limitations, we were able to answer our study questions. We could identify a specific tear pattern in these wheelchair-dependent patients: As distinguished from rotator cuff lesions in able-bodied patients, which are most frequently superior or posterosuperior, involving the SSP (and ISP) in 63%,[14] 57% of our study population had an anterosuperior lesion involving the SSC

and SSP tendons. Of the 61 shoulders (including all of the combined SSP and SSC lesions), 51 underwent additional surgery (tenodesis) on the long head of the biceps. These findings go along with the investigation of Popowitz et al,[16] who reported 100% SSP and 87.5% biceps tendon pathology rates in their series of paraplegic patients. Furthermore, in 16 paraplegic patients with a full-thickness rotator cuff tear, Escobedo et al[6] identified 100% involvement of the SSP tendon, with almost half of them having additional definitive discontinuity of the SSC tendon. They also found biceps tendon tears or dislocations to be more common in individuals with paraplegia than in able-bodied individuals. Similarly, a recently published study by Jung et al[12] showed SSC involvement in 9 of 16 shoulders. The etiology of this specific tear pattern might be explained by repetitive and forceful wheelchair propulsion, where the shoulder jerkily moves in a 70° abduction position from extension and internal rotation at the onset of the propulsive phase to flexion and external rotation at the onset of the recovery phase,[9] which potentially leads to an instable pulley with mechanical conflict of the long head of the biceps and the upper border of the SSC and/or anterior border of the SSP tendon.

Our structural failure rate of 33% is significant. This finding is not surprising considering that 75% of the repairs involved 2 or more tendons. Moreover, the retear rate for medium to large tears in able-bodied patients is between 49%[3] and 53%.[11] However, because the low fatty infiltration of the muscles preoperatively also would have been compatible with a lower rerupture rate, the high loads to which the repair is exposed after the primary rehabilitation period, as well as the significant number of patients (5 of 17) who had an early traumatic incidence, raise the suspicion of a particularly high risk of failure for wheelchair-bound patients.

To our knowledge, this is by far the largest series of rotator cuff repairs in wheelchair-dependent patients. Our study shows comparable clinical outcome scores (CS of 80 points, ASES score of 92 points, and SSV of 84%) to most of the previous reports of repairs in able-bodied patients, with postoperative CSs ranging from 74 to 85 points, ASES scores of 83 to 95 points, and 90% to 100% of patients being satisfied or very satisfied.[5,15] Our results are compatible with the good results of the 8 patients in the case series of Popowitz et al,[16] with an ASES score improvement from 34 to 84 points, as well as the findings of Jung et al,[12] who recently reported an ASES score improvement from 53 to 85 points and a CS improvement from 48 to 75 points (13 wheelchair-bound patients); however, our findings are in contrast to those in the series of Goldstein et al,[8] in which outcomes were not successful in 5 of 6 shoulders.

Conclusion

Failure of the rotator cuff in weight-bearing shoulders occurs primarily anterosuperiorly. Despite an overall failure rate of 33%, arthroscopic rotator cuff repair in weight-bearing shoulders of wheelchair-dependent patients leads to satisfactory clinical results with high patient satisfaction. In this study, the postoperative rehabilitation was carried out in a highly specialized institution and involved a mean length of hospitalization of 10 weeks. It may be that the excellent clinical outcome is dependent on such a postoperative regimen.

Disclaimer

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

References

1. Akbar M, Balean G, Brunner M, Seyler TM, Bruckner T, Munzinger J, et al. Prevalence of rotator cuff tear in paraplegic patients compared with controls. J Bone Joint Surg Am 2010;92:23-30. http://dx.doi.org/10.2106/JBJS.H.01373
2. Bayley JC, Cochran TP, Sledge CB. The weight-bearing shoulder. The impingement syndrome in paraplegics. J Bone Joint Surg Am 1987;69:676-8.
3. Boileau P, Brassart N, Watkinson DJ, Carles M, Hatzidakis AM, Krishnan SG. Arthroscopic repair of full-thickness tears of the supraspinatus: does the tendon really heal? J Bone Joint Surg Am 2005;87:1229-40. http://dx.doi.org/10.2106/JBJS.D.02035
4. Codsi MJ, Rodeo SA, Scalise JJ, Moorehead TM, Ma CB. Assessment of rotator cuff repair integrity using ultrasound and magnetic resonance imaging in a multicenter study. J Shoulder Elbow Surg 2014;23:1-5. http://dx.doi.org/10.1016/j.jse.2014.01.045
5. DeHaan AM, Axelrad TW, Kaye E, Silvestri L, Puskas B, Foster TE. Does double-row rotator cuff repair improve functional outcome of patients compared with single-row technique? A systematic review. Am J Sports Med 2012;40:1176-85. http://dx.doi.org/10.1177/0363546511428866
6. Escobedo EM, Hunter JC, Hollister MC, Patten RM, Goldstein B. MR imaging of rotator cuff tears in individuals with paraplegia. AJR Am J Roentgenol 1997;168:919-23.
7. Finley MA, Rodgers MM. Prevalence and identification of shoulder pathology in athletic and nonathletic wheelchair users with shoulder pain: a pilot study. J Rehabil Res Dev 2004;41:395-402.
8. Goldstein B, Young J, Escobedo EM. Rotator cuff repairs in individuals with paraplegia. Am J Phys Med Rehabil 1997;76:316-22.
9. Harburn KL, Spaulding SJ. Muscle activity in the spinal cord-injured during wheelchair ambulation. Am J Occup Ther 1986;40:629-36.
10. Hastings J, Goldstein B. Paraplegia and the shoulder. Phys Med Rehabil Clin N Am 2004;15:vii, 699-718. http://dx.doi.org/10.1016/j.pmr.2003.12.005
11. Huijsmans PE, Pritchard MP, Berghs BM, van Rooyen KS, Wallace AL, De Beer JF. Arthroscopic rotator cuff repair with double-row fixation. J Bone Joint Surg Am 2007;89:1248-57. http://dx.doi.org/10.2106/JBJS.E.00743
12. Jung HJ, Sim G-B, Jeon I-H, Kekatpure AL, Sun J-H, Chun J-M. Reconstruction of rotator cuff tears in wheelchair-bound paraplegic patients. J Shoulder Elbow Surg 2015;24:601-5. http://dx.doi.org/10.1016/j.jse.2014.09.028

13. Kulig K, Rao SS, Mulroy SJ, Newsam CJ, Gronley JK, Bontrager EL, et al. Shoulder joint kinetics during the push phase of wheelchair propulsion. Clin Orthop Relat Res 1998;354:132-43.
14. Melis B, Nemoz C, Walch G. Muscle fatty infiltration in rotator cuff tears: descriptive analysis of 1688 cases. Orthop Traumatol Surg Res 2009;95:319-24. http://dx.doi.org/10.1016/j.otsr.2009.05.001
15. Nho SJ. Systematic review of arthroscopic rotator cuff repair and mini-open rotator cuff repair. J Bone Joint Surg Am 2007;89(Suppl 3): 127-36. http://dx.doi.org/10.2106/JBJS.G.00583
16. Popowitz RL, Zvijac JE, Uribe JW, Hechtman KS, Schürhoff MR, Green JB. Rotator cuff repair in spinal cord injury patients. J Shoulder Elbow Surg 2003;12:327-32. http://dx.doi.org/10.1016/S1058-2746(03)00035-1
17. Robinson MD, Hussey RW, Ha CY. Surgical decompression of impingement in the weightbearing shoulder. Arch Phys Med Rehabil 1993;74:324-7.
18. van Drongelen S, Wolf SI, Fradet L. Muscle load in reaching movements performed by a wheelchair user: a case study. Disabil Rehabil 2013;36:1133-8. http://dx.doi.org/10.3109/09638288.2013.829527