ANALYSIS OF FATTY DEGENERATION OF THE TRAPEZIUS MUSCLE AFTER USE OF ACCESSORY NERVE

ANÁLISE DA DEGENERAÇÃO GORDUROSA DO MÚSCULO TRAPÉZIO APÓS USO DO NERVO ACESSÓRIO

Lucas Seiki Yamauti, Danielle Tiemi Simão, João Carlos Rodrigues, Luiz Koiti Kimura, Rames Mattar Junior

1. Universidade de São Paulo, Hospital das Clínicas, Medical School, Institute of Orthopedics and Traumatology, Hand and Microsurgery Group, São Paulo, SP, Brazil.

ABSTRACT

Objective: To investigate, through magnetic resonance imaging, the occurrence of fatty degeneration of the trapezius in adult patients undergoing nerve transfer procedure, using the spinal accessory nerve. Methods: A total of 13 patients meeting the criteria of unilateral brachial plexus injury and more than one year of postoperative care after nerve transfer surgery underwent an MRI scan of the trapezius. A T1-weighted 3D sequence was used, with the IDEAL technique using 8.0 mm cut thickness, 8.0 mm cut spacing, TR of 100 ms, TE of 3.45 ms, flip angle of 10 degrees, 20 cuts, on the sagittal plane. The images of the upper, transverse and lower parts of the trapezius muscle were then classified according to the degree of fatty degeneration, compared with the contralateral side, using the Goutallier score. Results: For the upper trapezius there was a change of the degeneration state in 23% (p = 0.083), for the transverse section there was a change in 84.6% (p = 0.003), for the lower one there was a change in 92.3% (p = 0.002). Conclusion: The upper trapezius did not undergo significant degeneration after transfer. The lower and transverse trapezius suffered fatty degeneration in most patients, indicating severe functional impairment. Level of Evidence IV, Case series.

Keywords: Accessory Nerve. Nerve Transfer. Muscle, Skeletal/Innervation. Magnetic Resonance Imaging.

INTRODUCTION

The accessory spinal nerve originates from cranial and spinal nerve roots in the posterior cranial fossa and innervates the sternocleidomastoid and the trapezius. After providing innervation to the sternocleidomastoid, the nerve descends obliquely into the posterior triangle of the neck. It branches (two to three branches in most cases) in the upper portion, before entering the trapezius. Intramuscularly, the nerve follows an oblique caudal course toward the middle and lower portion of the trapezius, branching to the muscle throughout its course.1 The accessory spinal nerve is often sacrificed and used in surgeries to repair brachial plexus lesions.2 Brachial plexus injury is usually caused by high-energy trauma, mainly involving the

RESUMO

Objetivo: Através de imagens de ressonância magnética, investigar a ocorrência de degeneração gordurosa no músculo trapézio em pacientes adultos submetidos a procedimento de transferência de nervo envolvendo o nervo espinhal acessório. Métodos: 13 pacientes com lesão do plexo braquial unilateral e mais de um ano de cirurgia de transferência de nervo foram submetidos a exame de ressonância magnética do músculo trapézio. Foram obtidas sequências 3D ponderadas em T1, com a técnica IDEAL, espessura de corte de 8,0 mm, espaçamento entre os cortes de 8,0 mm, TR de 100 ms, TE de 3,45 ms, flip angle de 10 graus e 20 cortes, no plano sagital. As imagens das porções superior, transversa e inferior do músculo trapézio foram classificadas de acordo com o grau de degeneração gordurosa e comparadas com o lado contralateral, utilizando o score de Goutallier. Resultados: Para o trapézio superior houve mudança no estado de degeneração em 23% (p = 0,083), para o trapézio transverso houve mudança em 84,6% (p = 0,003), e para o trapézio inferior houve mudança em 92,3% (p = 0,002). Conclusão: O trapézio superior não sofreu degeneração significativa após transferência. Os trapézios inferiores e médios sofreram degeneração gordurosa na maioria dos pacientes, indicando comprometimento funcional severo. Nível de Evidência IV, Série de casos.

Descritos: Nervo Acessório. Transferência de Nervo. Músculo Esquelético/Inervação. Imagem por Ressonância Magnética.

Citation: Yamauti LS, Simão DT, Rodrigues JC, Kimura LK, Mattar R Jr. Analysis of fatty degeneration of the trapezius muscle after use of accessory nerve. Acta Ortop Bras. [online]. 2020;28(4):186-9. Available from URL: http://www.scielo.br/aob.
traction mechanism, causing partial or total ruptures of nerve roots in the cervical spine and leading to severe dysfunction of the affected upper limb. The accessory spinal nerve is used in nerve transfers in the repair of high brachial plexus lesions and also as a motor nerve in free muscle flaps, usually with the aim of regaining shoulder and elbow function. This is due to the fact that the accessory spinal nerve is purely motor and close to the brachial plexus in the suprascapular region. It is possible to preserve function of the upper trapezius in nerve transfers, when the accessory spinal nerve is sectioned distal to the point of branching in the upper portion. The literature shows that partial or even total function of the trapezius can be maintained after injury to the accessory spinal nerve, since the trapezius also receives direct innervation of cervical roots. Therefore, there is still no understanding of how the trapezius evolves, especially its transverse and inferior portions, after the use of the accessory spinal nerve in nerve transfers. The aim of this study is to investigate, through magnetic resonance imaging, the occurrence of fatty degeneration of the trapezius (upper, transverse and inferior portions) compared to the contralateral side, in patients submitted to the nerve transfer procedure using the accessory spinal nerve.

MATERIALS AND METHODS

Study design

Thirteen adult patients with total or partial traumatic injury of the brachial plexus, with preserved trapezius and submitted to sacrifices and uses of the accessory spinal nerve, more than one year after surgery, underwent magnetic resonance imaging of the trapezius muscle after signing the informed consent form. Patients with indication for muscle transfers were prioritized for gaining external rotation of the shoulder and requiring detailed evaluation of trapezius trophism.

Positioning and acquisition of images

All images were obtained in a device with a magnetic field of 1.5 T (HDXT, General Eletric, Milwaukee, USA). To acquire the images, the patients were positioned in horizontal supine position, with the cervical-thoracic transition located in the isocenter of the equipment using a 16-channel cardiac coil (General Eletric, Milwaukee, USA). Initially, a tri-planar locator image was obtained with the echo gradient technique, echo time (ET) of 5 ms and repetition time (TR) of 15 ms. Next, a 3D sequence weighted in T1 was obtained, with the IDEAL technique (iterative decomposition and repetition time (TR) of 15 ms. Next, a 3D sequence weighted in T1 was obtained, with the IDEAL technique (iterative decomposition of water and fat, with echo asymmetry) using cutting thickness of 8.0 mm, spacing between the cuts of 8.0 mm, TR of 100 ms, ET of 3.45 ms, flip angle (FA) of 10 degrees, 20 cuts, oriented in the sagittal plane, favoring both the trapezius on the same side of the accessory nerve sacrificed, and the contralateral side without the lesion, using as reference its muscular origin in the spine and its distal insertion in the clavicle and spine of the scapula.

Image analysis

As a method to evaluate the evolution of the trapezius, for each patient, we used the classification of Goutallier et al. modified by Fuchs et al. for magnetic resonance imaging on the side where there was brachial plexus injury and on the side where there was no lesion, as control. Classification consists of five stages ranging from Stage 0 (normal muscle) to Stage 4 (more fat than muscle). The classification is described in Table 1.

The magnetic resonance images of the trapezius of the patients were evaluated by two observers, working independently and classified according to Goutallier et al. Side images were classified with brachial plexus injury/sacrifice of the accessory spinal nerve and the uninjured side. Then a consensus was established after a meeting with the two observers, reanalyzing the images, and reaching a single classification for cases that were initially classified in different stages by them.

Statistical analysis method

The data, the characteristics of patients and the Goutallier classification of the control (non-operated) side as well as the operated side were stored in an Excel spreadsheet for Mac and later imported into the SPSS® software for MAC. Categorical data were described by their frequency and their respective proportion and the continuous data by the mean and its respective standard deviation.

To verify whether there was a change in the Goutallier score between the sides of the 13 individuals analyzed, an inferential analysis was performed, using the nonparametric test for paired measurements, Wilcoxon Signed-Rank test. It was accepted as a statistically significant difference when the p value ≤ 0.05. The study was approved by the Ethics Committee of the Institution under number 1188 IOT Protocol and the Free and Informed Consent Form was signed by all participants.

RESULTS

Of the 13 study participants, 12 were male and one female, representing a percentage of 92.3% male and 7.7% female. The mean age was 40.62 ± 10.67 years. Nine patients (69.2%) presented high partial brachial plexus injury and four patients (30.8%) presented complete brachial plexus injury. The mean time between brachial plexus injury and surgery with the use of accessory spinal nerve was 10.85 ± 10.22 months. The mean time of postoperative care in procedures that used the accessory spinal nerve was 73.23 ± 46.26 months.

Eleven patients (84.5%) underwent an accessory spinal nerve transfer to the suprascapular nerve and two patients underwent a free functional muscle transfer procedure with the gracilis muscle, using the accessory spinal nerve as the motor nerve. Fatty degeneration of the trapezius was evaluated in the three portions of the muscle individually (upper trapezius, transverse trapezius and inferior trapezius) and on both sides, with the control being the side whose accessory spinal nerve was not sacrificed. The results of fatty degeneration according to the classification of Goutallier et al. modified by Fuchs et al. are shown in Table 2.
Table 2. Results of the analysis of fatty degeneration of the trapezius according to the classification of Goutallier et al.\textsuperscript{10} modified by Fuchs et al.\textsuperscript{11}

| Classification          | 0 | 1 | 2 | 3 | 4 | p-value |
|-------------------------|---|---|---|---|---|---------|
| Upper trapezius (Control n (%)) | 13 (100%) | 0 | 0 | 0 | 0 | 0.083   |
| Upper trapezius (Operated n (%)) | 10 (76.9%) | 3 (23.1%) | 0 | 0 | 0 | 0       |
| Transversal trapezius (Control n (%)) | 13 (100%) | 0 | 0 | 0 | 0 | 0.003   |
| Transversal trapezius (Operated n (%)) | 2 (15.4%) | 3 (23%) | 0 | 4 (30.8%) | 4 (30.8%) | 0.003   |
| Lower trapezius (Control n (%)) | 13 (100%) | 0 | 0 | 0 | 0 | 0.002   |
| Lower trapezius (Operated n (%)) | 1 (7.7%) | 1 (7.7%) | 1 (7.7%) | 2 (15.4%) | 8 (61.5%) | 0.002   |

Upper trapezius

Of the 13 participants recruited for the study, when comparing the control side with the operated side, the Goutallier score showed that there was a change in the state of fatty muscle degeneration in 23% of the individuals, from stage 0 to stage 1 (Figure 1). This observed modification was not statistically significant, with \( p = 0.083 \).

Transversal trapezius

Of the 13 participants recruited for the study, when comparing the control side with the operated side, the Goutallier score showed that there was a change in the state of fatty muscle degeneration in 84.6% of the individuals, from stage 0 to stage 1 (Figure 1). With 23% for stage 1 and 61.6% for stage 3 (Figure 2) or 4. This observed modification was not statistically significant, with \( p = 0.003 \).

Lower trapezius

Of the 13 participants recruited for the study, when comparing the control side with the operated side, the Goutallier score showed that there was a change in the state of fatty muscle degeneration in 92.3% of the individuals, from stage 0 to stage 1 (Figure 1). With 76.9% representing stage 3 or 4 (Figure 3A-B). This observed modification was statistically significant, with \( p = 0.002 \).

DISCUSSION

In traumatic brachial plexus injuries, there is a prevalence of involvement in males (about 89%), with an age range between 14 and 63 years and an average of 29 years.\textsuperscript{3} In the present study, 92.5% were male aged between 29 and 64 years and mean 40.62 ± 10.67 years. The mean time between brachial plexus injury and surgery with the use of accessory spinal nerve was 10.85 ± 10.22 months. The time was longer (over one year) in both cases in which the accessory spinal nerve was used as a motor nerve for free muscle transfer (gracilis muscle to brachial biceps muscle).

For nerve transfer procedures it is established that the maximum acceptable time is up to one year of brachial plexus injury.\textsuperscript{2} The 11 cases that underwent an accessory spinal nerve transfer procedure to the suprascapular nerve were operated less than one year after brachial plexus injury, as the literature suggests. The minimum evaluation time established of one year after surgery is due to evidence that, after one year of nerve injury, irreversible loss of motor neural plaques occurs due to degeneration and fibrosis.\textsuperscript{12} As the aim of this study is to evaluate fatty degeneration, we consider that after one year of sacrifice of the accessory spinal nerve, the areas innervated by it have already suffered degeneration, remaining only nerve stimuli by the direct cervical branches. Magnetic resonance imaging was chosen as it was capable of identifying and quantifying, in a noninvasive way, the morphology and muscular physiology. It is an examination already used in other studies to evaluate the appearance of the denervated muscle, which presents as characteristic the fatty degeneration.\textsuperscript{13-15} There is no previous study using magnetic resonance imaging to assess fatty degeneration of the trapezius after use or injury of the accessory spinal nerve.

The classification of Goutallier et al.\textsuperscript{10} was originally developed for chronic ruptures of the rotator cuff tendons. Muscle tissue, after chronic rupture of the tendon, is known to atrophy and retract,
REFERENCES

1. Dailiana ZH, Mehdian H, Gilbert A. Surgical anatomy of spinal accessory nerve: Is trapezius functional deficit inevitable after division of the nerve? J Hand Surg Br. 2001;26(2):137-41.

2. Wolfe S, Hotchkiss R, Pederson W, Kozin S, Cohen M. Green's operative hand surgery. 7th ed. Philadelphia: Elsevier; 2017.

3. Smarnia N, Berto G, La Marchina E, Meletti C, Midiri A. MRI appearance of muscle denervation in sheep. Am J Sports Med. 2017;45(3):651-8.

4. Chuang DC, Carver N, Wei FC. Results of functioning free muscle transplantation from cervical roots to the trapezius usually come from spinal nerves C3 and C4, but they cannot prove whether the transverse and lower portions of the muscle remain functional after a complete section of the accessory spinal nerve.

5. Bertelli JA, Ghizoni MF. Results of spinal accessory to suprascapular nerve transfers in 110 patients with complete palsy of the brachial plexus. J Neurosurg Spine. 2011;14(6):626-9.

6. Rui J, Zhao X, Zhu Y, Gu Y, Lao J. Posterior approach for accessory-supraspinatus nerve transfer: an electrophysiological outcomes study. J Hand Surg Br. 2013;38(4):343-7.

7. Tubbs RS, Shoja MM. Upper trapezius can be preserved if the accessory spinal nerve is sectioned distal to the point where there was branching in the accessory spinal nerve.9

8. Smeets C, van Bemmelen PP, van der Hauwaert L, van Beurden M, Vermeulen JP. Brachial plexus injury is a rare lesion, and the inclusion criteria used to assess fatty degeneration after denervation a muscle, we believe that this adaptation allows us to reliably evaluate fatty degeneration resulting directly from denervation, as we compare it with the healthy contralateral muscle.

9. Tubbs RS, Shoja MM, Loukas M, Lancaster J, Mortazavi MM, Hattab EM, et al. Anatomy of the accessory nerve. Eur Spinal J. 2013;22(3):299-306.

10. Gerber C, Meyer DC, Fluck M, Valdivieso P, von Rechenberg B, Benn MC, et al. Muscle degeneration associated with rotator cuff tendon release and/or denervation in sheep. Am J Sports Med. 2017;45(3):851-8.

11. Kim JH, Choi KY, Lee KH, Lee DJ, Park BJ, Rho YS. Motor innervation of the trapezius muscle. J Neurosurg Spine. 2011;14(6):626-9.

12. Tung TH, Mackinnon SE. Nerve transfers: indications, techniques and outcomes. J Hand Surg Am. 2010;35(2):332-41.

13. Kamath S, Venkataraesalingh N, Walsh MA, Hughes PM. MRI appearance of muscle denervation. Skeletal Radiol. 2008;37(5):397-404.

14. Zhang J, Zhang G, Morrison B, Mori S, Sheikh KA. Magnetic resonance imaging of mouse skeletal muscle to measure denervation atrophy. Exp Neurol. 2010;223(2):448-57.

15. Weber MA, Wolf M, Wattjes MP. Imaging patterns of muscle atrophy. Semin Musculoskelet Radiol. 2010;14(3):299-306.

16. Gerber C, Meyer DC, Fluck M, Valdivieso P, von Rechenberg B, Benn MC, et al. Muscle degeneration associated with rotator cuff tendon release and/or denervation in sheep. Am J Sports Med. 2017;45(3):851-8.

17. Kim JH, Choi KY, Lee KH, Lee DJ, Park BJ, Rho YS. Motor innervation of the trapezius muscle. Intraoperative motor conduction study during neck dissection. ORL J Otorhinolaryngol Relat Spec. 2014;76(1):8-12.