The Effect of Humerus Diaphyseal Shortening on Brachial Plexus Tension: A Cadaver Study

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Purpose To assess the extent to which diaphyseal shortening of the humerus can allow direct suture in case of rupture or transection injuries of the brachial plexus.

Methods The use of 3 fresh cadaver specimens allowed for the study of 6 brachial plexuses. Distance measurements were made between reference points placed on the clavicle and on different parts of the plexus. Those measurements were repeated after shortening the humerus by 2, 4, and 6 cm.

Results None of the dissected plexuses had classic anatomy. A humeral shortening of 6 cm allowed for a statistically significant reduction of length between the supraclavicular part of the plexus and the terminal branches, which did not exceed 17 mm on average. The difference of length was much greater for the specimen in which the musculocutaneous nerve did not pierce the coracobrachialis muscle proximally.

Conclusions In clinical situations, nerve defects are usually larger than the gain observed when doing a 6-cm humeral shortening. Moreover, this procedure implies a large dissection, a functional loss of certain muscles, and a risk of humeral nonunion.

Clinical relevance In the absence of extensive nerve dissection, the observed change of length is insufficient in the most brachial plexus disruptions to allow for a direct suture instead of long nerve grafts. *(J Hand Surg Am. 2015;40(2):303–307. Copyright © 2015 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Anatomical study, brachial plexus, humeral shortening.

Surgical options for posttraumatic brachial plexus repair and reconstruction include neurolysis, nerve suture, nerve grafting, nerve transfer, direct root re-implantation, and palliative procedures like arthrodesis and tendon transfers.[1–4] Elbow flexion is usually the treatment priority.[1–3,5,6] Direct suture of the ruptured nerves would probably be the best treatment option but is almost never possible. Nerve grafting then becomes the preferred treatment.

The results of nerve grafting cannot match those of a direct suture without tension, however, because it is impossible to correctly match the fascicles of the proximal donor with the recipient nerves.[5] Moreover, fiber regeneration has to cross 2 neurorrhaphy sites instead of 1, resulting in higher axonal loss.[7,8]

Another problem is that, in many cases, a plexus reconstruction requires a large quantity of nerve autografts that are often in short supply.[1,7,9,10] In a literature review conducted in 2011,[11] Gary reported that nerve transfer provided 96% good and 83% very good results for restoration of elbow flexion compared with nerve grafting, which provided 82% good and 56% very good results. Several authors use nerve transfers not only for avulsions but also for brachial plexus ruptures.[11–13] Another possibility to

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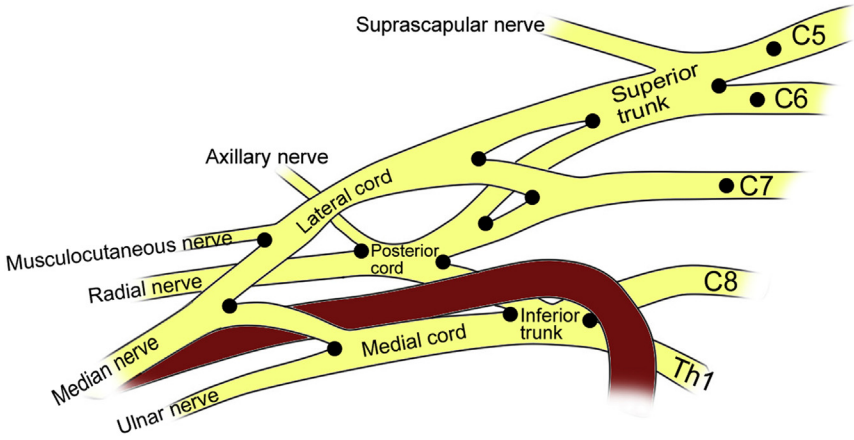

FIGURE 1: Diagram of the disposition of the suture markers on the elements of the brachial plexus.

avoid nerve grafting would be to perform a humeral shortening, which would theoretically make direct suturing possible. Humeral shortening has been performed by Yu et al[14] and Wang et al,[15] to transfer the contralateral C7 to the median and ulnar nerves without interposition of a nerve graft.

The purpose of this cadaveric study was to assess the effect of diaphyseal shortening of the humerus on the brachial plexus and more specifically to evaluate the possible benefits of this procedure in the treatment of brachial plexus ruptures. Through the dissection of cadaver specimens, we studied the hypothesis that, in some cases, humeral shortening could be used to allow direct suture and to avoid nerve grafts in patients with brachial plexus lesions.

METHODS

Three fresh cadavers without injury to their upper extremities were used for this study. After a 48-hour thawing at room temperature, each body was dissected on both sides, allowing for the study of 6 brachial plexuses. Throughout the procedure, the specimen was kept wet to prevent desiccation. An L-shaped incision was made along the lateral border of the sternocleidomastoid muscle and carried down across half of the clavicle and into the deltopectoral groove. The pectoralis minor muscle was detached from its proximal insertion on the coracoid process and the pectoralis major muscle was detached from the humerus. After almost complete exposure of the brachial plexus from the roots to the terminal branches, suture markers were placed as demonstrated in Figure 1. Another landmark was obtained by inserting a 1.5-mm Kirschner wire into the clavicle at its intersection with the subclavian artery. The humeral diaphysis was then exposed, which required section of the lateral head of the triceps brachii and of the tendons of the latissimus dorsi and teres major muscles. The circumflex vessels were located, and the proximal osteotomy site was marked distal to them. The distal osteotomy site was marked 6 cm farther distally. We measured this distance with an electronic precision caliper (accuracy, 0.1 mm). A six centimeter shortening was considered acceptable from an aesthetics point of view and sufficient for the majority of the nerve defects observed in brachial plexus injuries. Moreover, in the literature, no lengthening procedure is recommended in cases of upper extremity length inequality (ie, after epiphysiodesis or in congenital deformities) when the length difference is under 6 cm.[16,17]

At the end of the preparation, a wooden board was placed under the shoulders of the specimen and fixed to the table, allowing for a 90° arm abduction. A Hoffmann external fixator was then inserted, with two lateral pins in the humeral head, two pins distal to the distal osteotomy mark, and one pin in the great tuberosity. This last pin was parallel to the distal pins in order to control humeral rotation during the shortening procedure. The board was also connected to the external fixator so that the same degree of abduction could be maintained throughout the whole experiment. We then performed the humeral osteotomy using a sagittal saw.

Using the caliper, a first series of measurements was carried out between the clavicle landmark and the median, musculocutaneous, ulnar, and radial nerve landmarks with 0-, 2-, 4-, and 6-cm humeral shortenings. Each measurement was repeated three times and the calculated average of these measures was used for statistical analysis. The clavicle was then cut, allowing for the insertion of the last suture landmarks, in areas corresponding to the formation of