Bupivacaine Injection to Lateral Rectus in Abducens Nerve Palsy

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A 49-year-old female presented with bilateral abducens nerve palsies. She had 75 prism diopter esotropia. The extraocular movement of the lateral rectus was -1 limitation for the right eye and -4 limitations for the left. After performing orbital magnetic resonance imaging (MRI), 2 mL of bupivacain (5 mg/mL) was injected into the left lateral rectus (LR). One month after injection, a further orbital MRI was performed. Subsequently, recession of both medial rectus (6 mm) and resection of the left LR (9 mm) were performed. After one month, bupivacaine had no hypertrophic effects. There was little change in angle of deviation. The orbital MRI scan showed a 1.91% increase in volume compared to the muscle prior to the injection. Histological findings showed no muscle fibers of the left LR muscle, only the fiber nucleus and the collagen that replaced the fibers. We report on the changes in stiffness and muscle volume and on the histology of the muscle one month after injecting bupivacaine into the paralyzed left LR muscle combined with standard surgical treatment.

Key Words: Abducens nerve diseases, Bupivacaine, Magnetic resonance imaging

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injected into the LR. One month after injection, there was no change in deviation, and a further orbital MRI was performed (Fig. 1). Subsequently, the recession of both medial rectus (6 mm) and resection of the left LR (9 mm) led to orthotropia until 18 months (Fig. 2). At the left LR resection, traction testing demonstrated restriction of the medial gaze compared to before BUP injection. The formerly-injected LR was ‘stiff’ on surgical observation. The patient maintained orthotropia until 18 months.

**Discussion**

BUP selectively damages striated muscle fibers, leaving supporting cellular structures, nerves, and satellite cells intact [1-3]. The damaged tissue releases growth factors, causing satellite cells to proliferate. This process continues, causing hypertrophy. In most cases of complete paralysis, transposition of the rectus muscle is usually considered. However, in this study, recession of both the medial rectus muscle and resection of the paralyzed left lateral rectus muscle one month after BUP injection were performed. After injection of BUP, a hypertrophic effect on the paralyzed left LR muscle was expected; however, there was no change in the deviation of esotropia, and stiffness of the flaccid left LR muscle was observed one month after injection. Although it did not increase the effect on the muscle, BUP caused the observed stiffness. The patient maintained orthotropia until 18 months.

Orbital MRI images were used to measure muscle size with 3 mm slices from the orbital apex to the equator of the eye, coronally and axially. ITK-SNAP software (Penn Image Computing and Science Laboratory; University of Pennsylvania, Philadelphia, PA, USA) was used to evaluate any changes in MRI and to estimate muscle volume. Using the coronal plane, the incised surface of the left LR muscle was measured from the orbital apex to the junction of the extraocular muscle, and the volume calculated. The incised surface of the muscle was measured twice by different observers to reduce bias. The volume of the left LR muscle showed a 1.91% increase in volume compared to the muscle prior to the injection (Fig. 2). It was difficult to compare the changes in muscle volume due to the severity of the atrophy in the rectus muscle prior to the injection. Scott
et al. [5] reported a 6.2% increase in volume of the rectus muscle and changes of 6 PD when BUP was injected into the rectus muscle of an esotropic patient. Denervated muscle hypertrophy also occurs after bupivacain injection in animals, arguing for therapeutic trial in paretic strabismus [6]. However, in our subject, there were subtle increases in volume.

The paralyzed left LR muscle tissue, excised during surgery, was fixed in 10% neutral buffered formalin for 24 hours and fixed in paraffin blocks. The longitudinal axis of the muscle was sliced 10 μm thick and stained using Masson’s trichrome for histological examination. The normal LR muscle has two histologically significant layers. The global layer consists of larger fibers compared to the orbital layer and stains bright red with Masson’s trichrome solution. The orbital layer muscle fibers have smaller diameters and stain dark red with Masson’s trichrome solution [7-9]. In the abducens paralytic strabismus case presented, it was difficult to divide the two layers, and nuclei of muscle fibers and collagen that replaced the fibers were observed (Fig. 2). In addition, muscle biopsy did not document hypertrophy in this material.

LR paresis after injection of BUP and botulinum toxin into agonist and antagonist muscles have been reported [10]. One patient without LR atrophy was changed by 55 PD, and the other patient with LR atrophy was corrected only 4 PD after injection of BUP and botulinum toxin [10]. A large correction can be obtained in an incomplete paralyzed muscle so long as it is not atrophic. Muscle shortening and stiffening in BUP-injected LR were also demonstrated. We treated a patient with bilateral abducens nerve palsies, injecting with BUP to the complete paralyzed left LR along with standard surgery. The patient showed no muscle hypertrophy on MRI or deviation changes but did show muscle stiffness in the BUP-injected LR. Orthotropia was maintained, and adduction of the left eye was limited compared to that at six months due to stiffness of the injected left lateral rectus at 18 months.

**Fig. 2.** Photomicrographs of left resected lateral rectus after bupivacaine injection (×10, ×20). The nuclei of the muscle fibers and the collagen that replaced the fibers were observed (A), control (intermittent exotopia, 43-year-old woman, ×10, ×20) (B), Masson’s trichrome staining. Patient six months (C) and 18 months (D) after standard treatment (recession of both medial rectus muscles and resection of the left lateral rectus). Orthotropia is maintained, and adduction of the left eye is limited compared to that at six months due to stiffness of the injected left lateral rectus at 18 months.
The influence of BUP on atrophic extraocular muscle shows little benefit or change in muscle volume. The releasing growth factors causing satellite cells to proliferate might not be possible with severely atrophic muscle tissue. BUP injection to the atrophic muscle in this case was not useful for increasing muscle volume in a complete paralytic strabismus patient. However, the BUP-injected LR did exhibit muscle stiffening. It is possible that BUP injection to the complete paralyzed muscle has the effect of maintaining eye alignment after standard surgery even though there was no effect on muscle hypertrophy or deviation. BUP-injected atrophic muscle acts as a bridge for the complete paralytic strabismus patient with severe eye-movement limitation needing muscle transposition when combined with standard surgery. We will continue our efforts toward BUP injection to atrophic muscles in order to compare the effects of alignment between incomplete and complete paralytic patients combined with standard strabismus surgery.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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