CASE REPORT

Assessment of changes in masseter muscle by three-dimensional close-range photogrammetry after Botulinum toxin type-A injection: A case report with review of literature

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Abstract

Masseter muscle hypertrophy (MMH) is a benign, unilateral or bilateral, painless enlargement. Treatment protocols include surgical excision or a non-invasive option, using botulinum toxin type A (BTX-A). There is no study in the literature that measures this dimensional change in the masseter muscle (MM). The aim of this case report is to present changes in volume and surface area in MM with three-dimensional close-range stereophotogrammetry (3DCS). For treatment 30 units of BTX-A was injected into the three points hypertrophic muscle and patient records were taken to compare with 3DCS with a non-metric Canon EOS 550 D camera before and after injection. The changes in the surface area and volume of this muscle were mapped and the objective data were obtained.

This technique is useful for predicting the results of BTX-A application, and can be a useful tool for better physician-patient communication.

Keywords: BTX-A, Hypertrophy, Masseter muscle, Stereophotogrammetry, 3D model.

Introduction

BTX-A has been widely used for treating a variety of neuromuscular disorders, such as strabismus, blephorospasm, hemifacial spasm and torticollis, migraine, hyperhidrosis, esophageal achalasia, bruxism and masseter muscle hypertrophy (MMH). This hypertrophy is a benign, unilateral or bilateral, painless enlargement of the masseter muscle (MM). Treatment protocols include surgical excision or a non-invasive option, using botulinum toxin type A (BTX-A). BTX is a neurotoxin protein derived from the bacterium Clostridium botulinum and seven serotypes have been identified (A-G) until today. The mechanism of action is to inhibit the release of acetylcholine (ACH) from the presynaptic terminal of cholinergic nerve endings, thereby forming temporary muscle paralysis. Clinical observations suggest that there is a decrease in both the size and the volume of the BTX applied muscle due to developing paralysis.

Within our knowledge there is no study in the literature that measures this dimensional change in the MM. The aim of this study is to present three-dimensional (3D) close-range stereophotogrammetry method of changes in volume and surface area in MM after the administration of BTX-A.

In recent years, BTX-A has been widely used for treating a variety of neuromuscular disorders, such as strabismus, blephorospasm, hemifacial spasm and torticollis, migraine, hyperhidrosis, esophageal achalasia, bruxism, masseter hypertrophy (MMH), and oromandibular dystonia (OMD). In addition, many cosmetic indications have been known for botulinum toxin for eliminating crow's feet, vertical and horizontal lines around the eyes and lips, and scar management.[1-3]

BTX-A inhibits the exocytosis of acetylcholine on cholinergic nerve endings of motor nerves and blocks the release of acetylcholine by the neuron. This effectively weakens the muscle for a period of three to four months.[4]

Changes in muscle function, which are determined based on clinical observations, also bring about changes in muscle volume and area. The three-dimensional (3D) multi-view stereophotogrammetry method has recently been popular. With this technique, volume and area changes of soft tissues can be assessed and it can be used for different purposes such as evaluation of growth pattern or soft tissue changes after surgery. Comparative results can be achieved by performing mapping processing in the determined tissue.

The aim of this case report is to present changes in volume and surface area in MM after the administration of

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BTX-A with three-dimensional (3D) close-range stereophotogrammetry.

Case Report

A 25-year old male patient was admitted to Selcuk University, Faculty of Dentistry, Oral and Maxillofacial Surgery clinic at 10 December 2014 with complaint of facial asymmetry. Clinical and radiographic examination revealed that facial asymmetry developed due to benign hypertrophy of the left masseter muscle. The patient had no systemic diseases or relevant medical history. BTX-A injection was planned for treatment. After routine preparations were completed, 30 units of BTX-A was injected into the three points hypertrophic muscle according to technique previously described by Rijsdijk et al. in 1998.[5] Patient records were taken preoperative and first, second and third months after injection, to compare with 3D streophotogrammetry.

Photogrammetric Data Acquisition

The images were recorded inside of the Oral and Maxillofacial Surgery clinic, by hanging the specially contrived model on the wall and providing normal room lighting. The patient was positioned in a natural position and was asked to keep his head stable and to relax his facial musculature. A researcher experienced with photogrammetry took all of the photographs. The purpose of the indicated distortions, a camera self-calibration technique was implemented on twelve photographs. The calibration processes were carried out using Photomodeler, and Agisoft Lens commercial photogrammetric software.[6,7] The images were recorded with a non-metric Canon EOS 550 D camera with 18.7 megapixels, equipped with a CMOS sensor equal to 22.3 x 14.9 mm.

Photogrammetric Process

The lack of coordinate precision between the image coordinate conversion and the object space coordinate, however, meant that the project required ground control points (GCPs) for more accurate transformation.[8] These points are lateral cantus of eye, columella, lateral nasal wing, corner of the mouth, menton, tragus, inferior point of earlobe, the deepest point of the inner helix of the external auditory canal.

A 3D point cloud model was scaled with nose and ear distance in the first model. Afterward, the GCPs were exported from the first model for the same coordinate system for future period models for operations, analysis, and quality assessment.

A multi-photo, geometrically constrained and automated matching process was used to recover a dense point cloud of a complex object. The surface was measured fully automatically using multiple images, simultaneously deriving the 3D object coordinates. Once the point cloud and the surface of the patient were extracted, different operations and analyses were possible for 3D dentistry and facial applications of data. We conducted an analysis of the point cloud data's facial 3D images, such as volumetric comparisons before and after Botox® injections, and 3D comparisons of point clouds with multiscale model to model cloud comparison (M3C2)[9] implementation of the data. Volumetric computations were performed with meshed 3D models. For this purpose, we made the data sampling uniform to a 1 mm absolute distance between points. Thereafter, a surface model was created for the purpose of volume calculation and for surface area calculation. The reference plane that was located on the specific position as the four different periodic model volume computation could now be estimated; under the same reference plane.

Volumetric Comparisons

The volumetric comparisons procedure was applied (Table). Results showed that one month later 40 cm^3 decreases was identified in the hypertrophic masseter muscle, after two months 90 cm^3 decreases in the masseter volume and three months later 80 cm^3 decreases was seen. When the change in surface area was evaluated 1, 87 cm^2 reduction was seen at first month follow-up, 2, 26 cm^2 reduction after two months and 2, 22 cm^2 reduction was seen in surface area of the masseter muscle three months later (Table).

Table: The masseter muscle's surface region area and volumetric changings.

Date (Month/Year)	Surface Area (m^2)	Reference Plane Location (XY)	Volume (cm^3)	Differences in area (cm^2)	Differences in volume (cm^3)
12/2012	79.76		2790	Referece	Referemce
01/2013	77.89	0.5	2750	1.87	40
02/2013	77.50		2700	2.26	90
03/2013	77.54		2710	2.22	80

3D Comparison

The algorithm was designed for accurate orthogonal distance measurement between two point clouds. The comparison of the first evaluation and the second evaluation with the M3C2 algorithm showed a maximum 4.8 mm decrease in the masseter muscle. On the same region, a 4.2 mm decrease was observed in the first and the third evaluation comparisons. On the first and the fourth point cloud comparison, the masseter muscle region showed a 4 mm decrease (Figure-1).

3D comparison analysis was also implemented for C2C (cloud to cloud) absolute distance measurements between the two different point sets. The C2C analysis showed a change from 1.3 mm to 3.8 mm in the comparisons of the first point cloud and the second point cloud (pre-application and first month after application). In the second comparison (pre-application and second month after application), a 4 mm change was observed. In the third comparison(pre-application and third month after application), a 4.4 mm change had occurred.

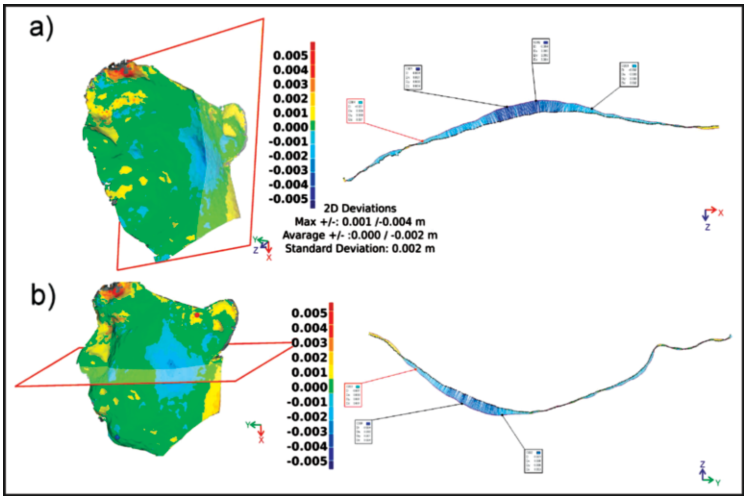

Figure-2: 2D profile on displacement region for detect movements on 2D planar drawing.

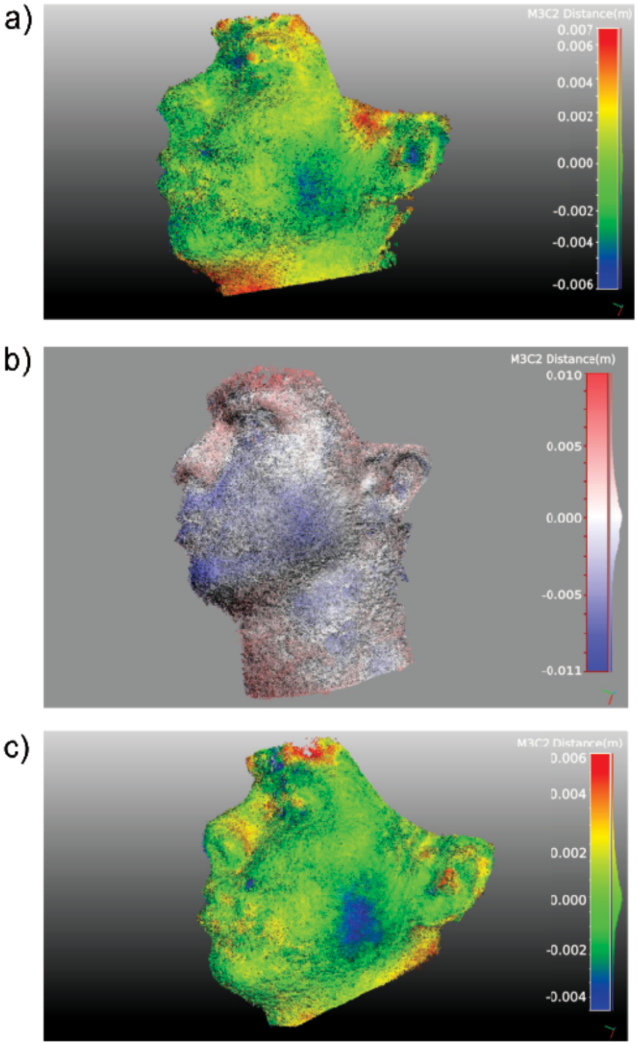

Figure-1: The algorithm was designed for accurate orthogonal distance measurement between two poinltcouds.

3D mesh analyses are also possible with meshed surface models. 3D mesh comparisons are calculated with derivations of models from the reference (first epoch) model. In terms of the 3D mesh comparison algorithm, the first mesh model (injection month) and the second mesh model (one month after BTX-A) comparison showed a 1 mm-3 mm decrease of the swelling on the MM. The first mesh model and the third mesh model (second month after BTX-A) comparison showed decreases of 1 mm-4 mm on the hypertrophic region. The first mesh model and the fourth model (third month after BTX-A) comparison also showed a decrease of around 1 mm-4 mm on the MM. Further analyses were executed with 2D on the surface profiling to detect changes in two dimensions. This makes it easy to interpret the displacements of the points in planar drawings (Figure-2).

At first, second and third month controls the distinct reduction in the contour of the left cheek was seen in the patient. Through the application of BTX-A, the patients had aesthetic benefits, and the pain associated with their bruxism complaints was resolved. Through the implementation of BTX-A, a symmetrical appearance occurred based on atrophy in the MM fibers over time. 3D close-range photogrammetry was used in order to objectively evaluate the reduction in patient complaints and changes in the MM before and after BTX-A treatment.

Discussion

Photogrammetry is the process of performing indirect measurements of an object space by using photography, and the process of extracting information from two-dimensional (2D) images, applying mathematical transformations and functions, and mapping them onto a 3D space.[8,10] 3D close-range photogrammetry has various uses, such as the analysis of facial soft tissue profiles before and after orthognathic surgery,[11] in the rehabilitation of maxillofacial deformities,[12] and for assessing soft tissue characteristics of facial asymmetry.[13,14] This technique has been found to be beneficial for evaluating pre- and postoperative volumetric changes from maxillofacial surgery.[15] Verhoeven et al. designed a study[12] that used 3D stereophotogrammetry to evaluate soft tissue facial asymmetry after mandibular reconstruction. They used this method on 15 mandibular reconstruction patients and 24 healthy controls and they concluded that 3D stereophotogrammetry is a useful, practical, and applicable method for evaluating facial asymmetry. In another study, 3D stereophotogrammetry was used for the analysis of facial growth in a paediatric reconstructed mandible.[16] Kau et al. (2011)[17] used this method on a child who had undergone mandibular segmental resection to evaluate facial growth over the course of two years. Over the two years, the patient showed significant positive changes and some negative changes. A colour map was provided to view the positive and negative changes in the face during this period. They concluded that this method can be used for objectively measuring and observing facial growth and facial changes. Worasakwutiphong et al.[18] used 3D stereophotogrammetry to evaluate nasal changes after orthognathic surgery (two-jaw surgery) in thirty-eight mandibular prognathic and Class III malocclusion patients. The authors concluded that 3D stereophotogrammetry is useful for evaluating nasal and other soft tissue changes after orthognathic surgery.

In this study, we used 3D stereophotogrammetry to evaluate facial contour change for the patient with masseter muscle hypertrophy after BTX- A implementation. In another word, we tried to mapping the facial contour after the treatment. Volumetric and 3D comparisons were performed for mapping the changes. In this case, three-month follow-up results showed that in the second month, the volumetric and surface area reduction in the masseter muscle reached its maximum. After that, the volume and surface area of muscle began to increase. Additionally, 3D comparison method assessed the distance measurement between the two point clouds in the masseter and it was determined that in the first month after the BTX- A application the masseter reduction was more than the second and third month controls.

In order to assess outcomes of BTX treatment, photography, magnetic resonance imaging (MRI), computed tomography, high-resolution ultrasound and 3D images can be used to show how BTX implementation will affect facial contours. 3D close-range photogrammetry is a recent technique that can evaluate facial soft tissue thickness, volume, and curvature by using photography.[19-22] The 3D close-range photogrammetry technique makes the comparison and interpretation of mesh comparison analysis easier than point cloud analysis. Point cloud comparison analysis is impressionable from noisy data, which can lead to difficulty in interpretations. The mesh model comparisons, in contrast, are resistant to these errors, and it is easy to analyze the results.

This technique is useful for predicting the results of BTX-A application, and can be a useful tool for better physician-patient communication. To the best of our knowledge, this study is the first report to evaluate volume and area changes in the masseter muscle after BTX-A implementation by using 3D close-range photogrammetry. This case shows that the 3D close-range photogrammetry technique that can be used to analyze changes of the muscles. Conducting studies to evaluate dose-related outcomes and long-term effects, however, will guide clinicians, particularly with regard to possible changes in facial region applications.

Conclusion

Within the limitations of this study, 3D stereophotogrammetry are useful for assessing the general appearance and aesthetics of muscles after BTX-A application.

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