Int. J. Oral Maxillofac. Surg. 2010; 39: 534–540
doi:10.1016/j.ijom.2010.03.022, available online at http://www.sciencedirect.com

International Journal of
Oral & Maxillofacial Surgery

Clinical Paper
Cleft Lip and Palate

3D Stereophotogrammetric assessment of pre- and postoperative volumetric changes in the cleft lip and palate nose

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B. van Loon, T. J. Maal, J. M. Plooij, K. J. Ingels, W. A. Borstlap, A. M. Kuijpers-Jagtman, P. H. Spauwen, S. J. Bergé: 3D Stereophotogrammetric assessment of pre- and postoperative volumetric changes in the cleft lip and palate nose. Int. J. Oral Maxillofac. Surg. 2010; 39: 534–540.

Abstract. In cleft lip and palate patients the shape of the nose invariably changes in three dimensions (3D) due to rhinoplastic surgery. The purpose of this study was to evaluate stereophotogrammetry as a 3D method to document volumetric changes of the nose in patients with a cleft lip (CL) or cleft lip and palate (CLP) after secondary open rhinoplasty. 12 patients with unilateral CL or CLP were enrolled in the study prospectively. 3D facial images were acquired using 3D stereophotogrammetry preoperatively and 3 months postoperatively. A 3D cephalometric analysis of the nose was performed and volumetric data were acquired. The reliability of the method was tested by performing an intra- and inter-observer analysis. Left, right and total nasal volumes and symmetry were compared. No statistically significant differences ($p < 0.05$) were found within and between observers for the measured volumes and symmetry. Postoperatively, the total volume of the nose increased significantly, especially the volume at the cleft side. No significant volume difference pre- and postoperatively was found for the non-cleft side. The symmetry of the nose improved significantly. 3D stereophotogrammetry is a sensitive, quick, non-invasive method for evaluating volumetric changes of the nose in patients with cleft lip or cleft lip and palate.

Keywords: stereophotogrammetry; cleft lip and palate; rhinoplasty; volumetric 3D measurements; reproducibility; surface registration; maxillofacial surgery; otorhinolaryngology; plastic and reconstructive surgery.

Accepted for publication 23 March 2010
Available online 27 April 2010

The nose is known to be aberrant in appearance and function in patients with a cleft lip (CL) or a cleft lip and palate (CLP)[3]. Distortions of the nose can vary from almost invisible to catastrophic, mostly dependent on the severity and type of cleft[29]. To correct the nasal deformity in CL or CLP patients is a challenge. In the Netherlands, for the last 25 years, a primary rhinoplasty correction has been performed at the time of primary lip closure in unilateral CL or CLP patients. This usually involves reducing the asymmetry by undermining and rotating the nose without altering bony tissue. Nevertheless, as the children grow older, the nasal shape remains deformed. There is usually an underprojection of the dome at the cleft

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side and surgery mainly focuses on correcting this asymmetry by increasing the projection (which enhances the volume of the nasal pyramid) on the cleft side.

Various studies have been undertaken to evaluate the result of different rhinoplastic procedures[3,10,12,13,16,19,21,25], but quantification of surgical changes remains difficult. Besides direct anthropometric measurements[7], two-dimensional (2D) photographs and radiographs are used to document and calculate the changes after surgery[23]. Until now, studies comparing pre- and postoperative nasal changes in patients with clefts have been limited to these techniques[15]. The human body however, is a three-dimensional (3D) entity and any change, whether from movement during facial expression or from surgery, occurs in three dimensions. Various 3D imaging techniques have been developed to overcome the shortcomings of conventional 2D imaging. These include 3D cephalometry[26], Moiré topography[28], 3D laser scanning[6], 3D optoelectronic digitizers[8] and 3D stereophotogrammetry[11,14,24]. The latter method has gained popularity over the last years as digital 3D data sets of the face can be acquired rapidly and non-invasively, while simultaneously being archived for future analysis[2]. Recent studies have shown 3D cephalometric measurements acquired with a 3D stereophotogrammetrical camera setup to be valid and reproducible[2,22].

To the best of the authors' knowledge, no stereophotogrammetry studies have been performed on the volumetric 3D changes of the nose after secondary rhinoplasty in CL and CLP patients. The purpose of this study was to evaluate the value of 3D stereophotogrammetry for volumetric documentation of the nose in CL and CLP patients who underwent secondary rhinoplastic surgery.

Materials and methods

The study sample comprised of CL and CLP patients from the Cleft Palate Craniofacial Unit of the Radboud University Nijmegen Medical Centre, Nijmegen, The Netherlands, operated on between June 2007 and December 2007. Inclusion criteria were: unilateral CL or unilateral CLP; age above 12 years; and signed informed consent. Exclusion criteria were: associated cranio-facial deformities; syndromes; and earlier secondary rhinoplastic surgery.

Operative procedure

All operative procedures were performed by one surgeon (PS). An open rhinoplasty (Rethi incision: rim incision traversing the columella) was performed in all patients. Depending on the deformity, the following nasal surgery components were employed: a septal deviation was corrected by remodelling the deviating septum and trimming the base. The lower lateral cartilages were reduced and sutured together in order to narrow the dome. A columellar strut was placed for nasal tip support. For this purpose part of the septal cartilage was used or cartilage was acquired from the auricular concha. Dome sutures, shield, tip or dorsal grafts were implemented if required. When correction of the nasal bone was mandatory a medial and lateral osteotomy including efracture and infracture was performed.

Pre- and postoperative 3D documentation

A 3D stereophotogrammetrical camera setup with an integrated software program modular system V 1.0 (3dMDface™ System, 3dMD LLC, Atlanta, GA, USA) was

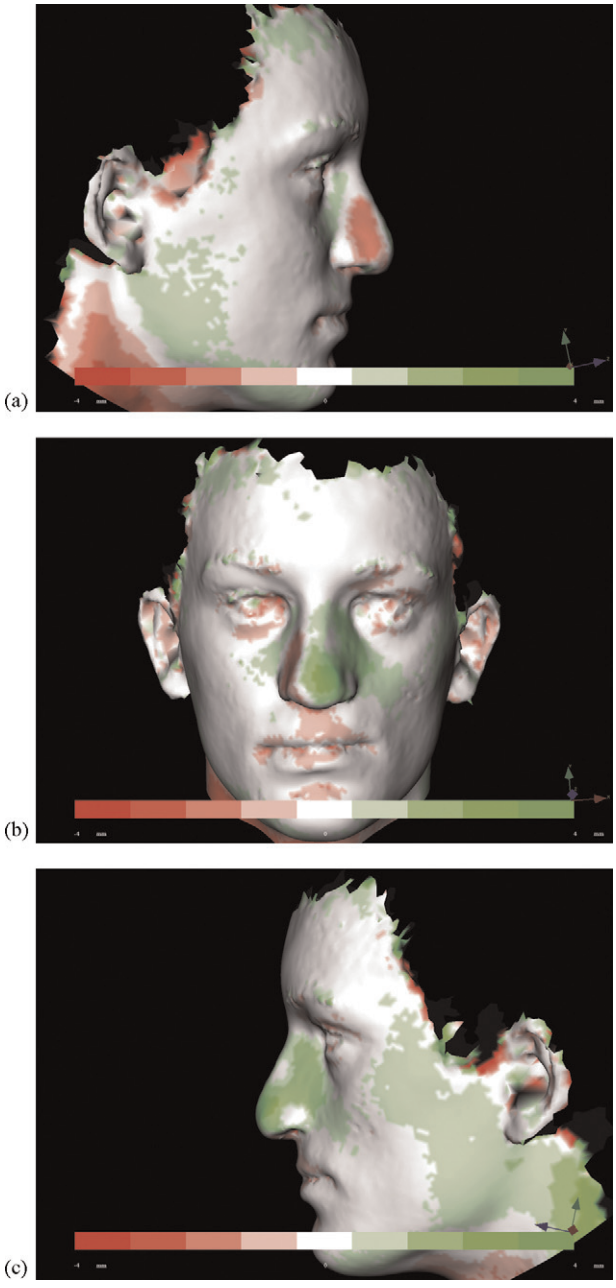

Fig. 1. 3D distance map of the pre- and postoperative soft tissue changes in patient 6. (a) Decrease (red) of volume on the non-cleft side; (b) patient 6 frontal view; (c) increase (green) in volume on the cleft side.