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A systematic review on soft-to-hard tissue ratios in orthognathic surgery part II: Chin procedures

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ABSTRACT

Purpose: Precise soft-to-hard tissue ratios in orthofacial chin procedures are not well established. The aim of this study was to determine useful soft-to-hard tissue ratios for planning the magnitude of sliding genioplasty (chin osteotomy), osseous chin recontouring and alloplastic chin augmentation.

Material and methods: A systematic review of English and non-English articles using PubMed central, ProQuest Dissertations and Theses, Science Citation Index, Elsevier Science Direct Complete, Highwire Press, Springer Standard Collection, SAGE premier 2011, DOAJ Directory of Open Access Journals, Sweetswise, Free E-Journals, Ovid Lippincott Williams & Wilkins total Access Collection, Wiley Online Library Journals, and Cochrane Plus databases from their onset until July 2014. Additional studies were identified by searching the references. Search terms included soft tissue, ratios, genioplasty, mentoplasty, chin, genial AND advancement, augmentation, setback, retrusion, impaction, reduction, vertical deficit, widening, narrowing, and expansion.

Study selection criteria were as follows: only academic publications; human patients; no reviews; systematic reviews or meta-analyses; no cadavers; no syndromic patients; no pathology at the chin or mandible region; only articles of level of evidence from I to IV; number of patients must be cited in the articles; hard-to-soft tissue ratios must be cited in the articles or at least are able to be calculated with the quantitative data available in the article; if all patients of one article have had bilateral sagittal split osteotomy (BSSO) performed along with chin osteotomy, there should be an independent group evaluation of the data concerning to the chin; and no restriction regarding the size of the group. Independent extraction of articles by two authors using predefined data fields, including study quality indicators (level of evidence).

Results: The search identified 22 articles. Eleven additional articles were found in their reference sections. Of these, two were evidence level IIIb, three were evidence level IIb, and the rest were evidence level IV. Three studies were prospective in nature. A high variability of soft-to-hard tissue ratios regarding genioplasty seemed to disappear if data were stratified according to confounding factors. With the available data, a soft-to-hard pogonion ratio of 0.9:1 and 0.55:1 could be used for chin advancement and chin setback surgery, respectively.

Conclusion: Advancement and extrusion movements of the chin segment show respectively a 0.9:1 of sPg:Pg horizontally and 0.95:1 of sMe:Me vertically. Setback and impaction movements show respectively a −0.52:1 of sPg:Pg horizontally and −0.43:1 of sMe:Me vertically. Prospective studies are needed that stratify by confounding factors such as type of osteotomy technique, magnitude of the movement, age, sex, race/ethnicity, and quantity and quality of the soft tissues. More specifically, studies are needed regarding soft-to-hard tissue changes after chin extrusion ("downgrafting"), intrusion ("impaction"), and widening and narrowing surgery.

1. Introduction

Facial harmony is the consequence of proper balance between the different parts of the face. A well-proportionated chin can

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dramatically contribute to facial harmony, especially in profile view (Chen et al., 2007). Moreover, a prominent chin is associated with the perception of a strong character (Annino, 1999).

In order to achieve a specific shape and projection of the chin, a set of mandibular osteotomies has been defined in the course of years to allow spatial movements of advancement, retrusion, extrusion, intrusion, widening, and narrowing.

The most common procedure to correct a retruded chin is chinbone advancement, which is performed with a horizontal "sliding" osteotomy at the inferior border of the mandible. Otto Hofer (1942) was the first surgeon to describe the chin advancement osteotomy, which was performed by an extra-oral approach, although the "patient" seems to have been a cadaver. Gillies and Millard (1957) performed the same procedure on a living patient, also using an external approach. Trauner and Obwegeser (1957) were the first surgeons to perform a chin advancement osteotomy through an intraoral approach and dubbed the technique "genioplasty". Chin setback can also be performed via a sliding genioplasty technique. Hinds and Kent (1969) were the first to describe setback genioplasty in a scientific article. Vertical chin height reduction, also called intrusion or impaction genioplasty, was first described by Reichenbach et al. (1965) by removing a wedge of bone in the middle of the symphysis. Chin extrusion ("downgrafting" or vertical height augmentation genioplasty) was first described by Converse and Wood-Smith (1964) with the insertion of a bone graft into the horizontal osteotomy site. From a frontal view, the chin can also be widened or narrowed. Several procedures have been proposed to treat an asymmetric chin, either by using alloplastic material (Bell and Gallagher, 1983) or by performing specific osteotomies (Raffaini and Sesenna, 1995). Park and Noh (2008) were the first authors to publish on bilateral narrowing of the chin for aesthetic purposes, by means of a horizontal osteotomy and resection of a central bone fragment. Narrowing genioplasty, in combination with angle and body of the mandible osteotomy, is indicated to slender a square face type, and has gained interest among patients who require facial feminization and also patients of Asian descent (Khadka et al., 2011; Chen et al., 2011, 2013; Mommaerts, 2013a). Widening genioplasty is less common. Symphyseal widening with a distraction device is used in absolute transverse mandibular deficiency (Guerrero, 1990; Mommaerts, 2001). Chin proper widening osteotomy was proposed by Epker et al. (1995) by dividing the chin segment and interpositioning a bone graft. Reyneke and Sullivan (2001) proposed a simplified technique by midline osteotomy of the chin segment and anterior rotation of the fragments.

Apart from chin osteotomy, different implants have been used to give volume to the chin. Silicone (Friedland et al., 1976), polytetrafluoroethylene (PTFE) (Parkes et al., 1976), polyester (Gross et al., 1999) polyethylene (PE) (Shaber, 1987), and polymethylmethacrylate (Karras and Wolford, 1998) have been the most common materials used for making implants for chin augmentation.

When a chin implant is placed or when a chin osteotomy is performed and the implant or segment is fixed in a new position, the soft tissues will follow in a degree that is measured using soft-to-hard tissue ratios. Each ratio explains how much a certain soft-tissue landmark will move in relationship to a certain hard-tissue landmark. For example, a ratio of 0.9:1 between soft Pogonion (sPg) and hard Pogonion (Pg) means that for each 10 mm of anterior movement of Pg, sPg will follow 9 mm. The rationale for the research was that precise soft-to-hard tissue ratios in orthofacial chin procedures are not well established. Knowledge of how soft tissue moves in relation to hard tissue will provide better outcome predictions when using the facial profile line for planning (Mommaerts, 2013b) and Photoshopping simulations are performed (Mommaerts, 2013c; Büttner and Mommaerts, 2015), which in turn can help the patient tune his/her sliding genioplasty. Our objective was to determine useful soft-to-hard tissue ratios for planning the magnitude of a sliding chin osteotomy, osseous recontouring, and alloplastic augmentation.

2. Material and methods

2.1. PICOS

The study population included all patients who had received a genioplasty. The intervention was a chin osteotomy with repositioning of the segment in all directions, or a chin augmentation procedure with alloplastic or autologous materials. There was no comparator. Outcomes were based on the soft-to-hard tissue ratios in the mid–sagittal plane. Study designs included randomized and observational studies, cohort studies and case reports.

2.2. Literature search

The systematic literature search (shown as a QUOROM-flow diagram (Moher et al., 1999)) (Fig. 1) was started with the assistance of Unika Library Service from the University of Navarre (Clínica Universitaria de Navarra, Pamplona, Spain). This Service allowed the authors to use PubMed central, ProQuest Dissertations and Theses, Science Citation Index, Elsevier Science Direct Complete, Highwire Press, Springer Standard Collection, SAGE premier 2011, DOAJ Directory of Open Access Journals, Sweetswise, Free E-Journals, Ovid Lippincott Williams & Wilkins total Access Collection, Wiley Online Library Journals, and Cochrane Plus databases. The heading sequence ("Soft Tissue" OR "Ratios") AND ("Genioplasty" OR "Mentoplasty" OR "Chin" OR "Genial") AND ("Advancement" OR "Augmentation" OR "Setback" OR "Retrusion" OR "Impaction" OR "Reduction" OR "Vertical Deficit" OR "Widening" OR "Narrowing" OR "Expansion") was selected. Our initial search returned 4008 published articles till July 2014. Inclusion criteria mandated only academic publications, and the number of articles decreased to 980. No language restriction was used. Articles discussing non-human animals, cadavers, or a different topic were excluded, after which 305 potential articles were found. Articles about syndromic cases, pathologic cases, meta-analyses, Level of Evidence V, and mandibular alveolar subapical osteotomies, were excluded; remaining 50 articles. Of these, 22 fulfilled inclusion criteria 8, 9, and 10 (see Selection criteria). To complete the search, the references of each selected publication were searched by hand, and abstracts of congress/convention proceedings online were searched on line. A total of 25 additional articles were found, 11 of which fulfilled the selection criteria. With the addition of these 11 articles, a total of 33 articles were included in this systematic review.

2.3. Selection criteria

Selection criteria (inclusion and exclusion criteria) were chosen to select potential articles from the published abstract results: 1) only academic publications; 2) human patients; 3) no reviews, systematic reviews or meta-analyses; 4) no cadavers; 5) no syndromic patients (i.e., Pierre Robin syndrome); 6) no pathology at the chin or mandible region; 7) only articles of level of evidence from I to IV (level V are excluded); 8) number of patients must be cited in the articles; 9) hard-to-soft tissue ratios have to be cited in the articles or, at least, they are able to be calculated with the quantitative data available in the article; 10) if all patients in one article have had bilateral sagittal split osteotomy (BSSO) performed