Evaluation of Olfactory and Gustatory Function Following Orthognathic Surgery

David C. Sanger
An Evaluation of Olfactory and Gustatory Function Following Orthognathic Surgery

David C. Sanger, Jr., DDS

In partial fulfillment of the requirements for a Certificate in Orthodontics

Major Advisor: April Mott, MD
Co-Advisors: Louis Norton, DMD
             David Shafer, DMD

University of Connecticut
1993
ABSTRACT

A common complication of orthognathic surgery is paresthesia resulting from damage to nerves coursing the orofacial complex. Many of these nerves have a chemosensory component carrying information regarding olfaction and gustation. To determine the effects of orthognathic surgery on taste and smell function, chemosensory evaluations were performed on patients presenting to the University of Connecticut Oral and Maxillofacial Surgery Clinic. Evaluations were performed two weeks prior to surgery, then again two and six months following surgery. Olfaction was measured using forced choice threshold and odor identification techniques, while gustation was measured using both whole mouth and spatial evaluation tests. Preliminary findings showed that whole mouth scores dropped significantly two months following surgery. Evaluation six months post surgery revealed improvements in some patients. Spatial taste data showed distinct areas of aguesia two months after surgery, with some aguesic areas regaining taste function four months later. Olfactory function did not differ significantly after surgery. None of the subjects reported subjective taste or smell alterations at any time following the surgical procedures.


**Introduction**

Orthognathic surgical procedures allow manipulation of the maxilla and mandible for correction of a variety of craniofacial deformities. Possible post-operative sequelae include damage to surrounding hard and soft tissue structures. Transient and permanent paresthesias have been reported as a result of injury to nerves in the surgical sites. Many of these nerves have a chemosensory component carrying information regarding olfaction and gustation. In the present study, it is hypothesized that orthognathic surgical complications may also manifest as chemosensory dysfunction. Currently, the medical and dental literature does not address the impact of orthognathic surgery on olfaction or gustation. The present study will evaluate chemosensory function following Le Forte I osteotomy, bilateral sagittal split ramus osteotomy, or a combination of both.

**Surgical Procedure - Le Forte I Osteotomy**

Separation of the maxilla from its bony housing allows the surgeon to manipulate the position of the maxilla in an effort to correct a variety of orofacial deformities. The procedure involves the sectioning of the lateral maxillary walls, the lateral nasal walls and the nasal septum (Fig 1). Incisions are made posterior to the maxillary tuberosities bilaterally to separate the maxilla from the pterygoid plates, bilaterally along the maxillary walls at the base of the zygomatic process to a point approximately 1 cm above the floor of the nasal cavity, and horizontally to
separate the nasal septal cartilage and vomer. The lateral nasal bone is sectioned at a level below the attachment of the inferior turbinate. The remaining posterior attachment is purposely fractured by applying a downward force to the maxilla. In this way an attempt is made to spare the greater palatine nerve and artery as the bone fractures around the foramen leaving its contents intact. Once disarticulated, the maxilla can be uniformly or differentially impacted or descended, rotated about its vertical axis, or moved in an anterior/posterior direction. The maxilla can also be separated into segments for the correction of transverse discrepancies.

**Surgical Procedure - Bilateral Sagittal Split Ramus Osteotomy**

Manipulation of the mandible is commonly used for the correction of prognathism, retrognathism or vertical discrepancies. The procedure involves bilateral oblique cuts from the retromolar area to the gonial angle, horizontal cuts through the medial ramus superior to the lingula, then a split sagitally between the two cuts (Fig. 2). The mandible is then free to slide or rotate in any direction. Because this procedure is technically difficult, a variety of modifications have been made in an effort to reduce morbidity. Paresthesias are a common complication due to the proximity of the inferior alveolar and lingual nerves in the region.

It is common that both maxillary and mandibular surgery are indicated for the correction of severe dentoskeletal deformities. Concurrent orthodontic treatment is usually necessary to produce optimal dental results.
**Olfaction**

As the first step in the olfactory process, odorant molecules enter the nasal cavity by passing through the external nares during inhalation, or by passing the posterior choanae during exhalation. A 1 cm² section of mucosa lying between the nasal septum and lateral nasal wall at the top of the nasal cavity is comprised of a specialized olfactory epithelium. Here, chemical odorants are dissolved, bind to olfactory receptors and are translated into electrical signals. Olfactory receptor axons traverse the cribriform plate of the ethmoid bone to synapse in the olfactory bulb. Secondary neural pathways then project to the olfactory cortex, orbitofrontal cortex, thalamus, and hypothalamus. The mucous membrane of the nose also contains somatic sensory fibers of the trigeminal nerve responsible for such perceptions as the tingling of ammonia.

There are a variety of surgical procedures that have been reported to affect the sense of smell. Champion found that approximately 10% of 200 subjects who had undergone rhinoplasty reported temporary anosmia from several days to two years, with most ranging from six to eighteen months. Anosmia was thought due to obstruction caused by edema, blood clots or packs, or due to mucous membrane injury. Moore et al., reported deleterious effects on olfaction as a result of inferior turbinectomy for nasal obstruction. As a consequence of the surgery, he found a disruption in the normal physiologic effect of the nose (warming, humidification, filtration) resulting in drying, crusting, infection and scarring of the mucosa. Ophir, however, did not find these atrophic changes and found no deleterious effect on olfaction following inferior turbinectomy.

Surgical procedures such as ethmoidectomy and correction of
anomalies such as hypertelorism\textsuperscript{25} have also been implicated in olfactory dysfunction.

While orthognathic surgery has not been reported to influence olfaction, previous studies have shown that repositioning of the maxilla does affect nasal respiration.\textsuperscript{29, 15} When considering impaction surgery, one might suspect that nasal respiration would be hindered as the maxilla impinges upon the nasal airway space. However, it has been shown that nasal airway resistance decreases following Le Forte I impaction procedures. This is due to a widening of the nares as the maxilla is superiorly positioned.\textsuperscript{17, 28} A decrease in nasal airway resistance has also been reported following surgical maxillary expansion\textsuperscript{18, 30} resulting from similar changes in the nasal architecture.

Because nasal resistance has been reported to change following Le Forte I maxillary procedures, it might follow that olfaction changes similarly. It is unclear whether changes in nasal airway resistance are associated with changes in olfactory ability. Eccles\textsuperscript{12} found no relationship between nasal airway resistance and thresholds for olfactory or trigeminal stimulants in normal patients. Ghorbanian\textsuperscript{14} however, suggested that, in children with varying degrees of nasal obstruction, the obstruction was associated with olfactory impairment, and that a decrease in the obstruction was followed by an improved ability to smell. Doty,\textsuperscript{11} in a review article, found both improvements and impairments in smell function following surgical intervention for disturbances in nasal airflow function.

Impingement upon the nasal airway space may be a possible etiologic factor for alterations in olfaction found following orthognathic surgery.
Also, if the nasal septum is incompletely separated, downfracturing of the maxilla may damage the cribriform plate of the ethmoid bone as it is released from the nasal septum. Other possible etiologic factors include mucous membrane injury, and obstruction following edema, infection or scarring.

**Gustation**

While there are regional differences in taste acuity, all four basic taste qualities can be detected throughout the mouth. The chorda tympani branch of the seventh cranial nerve supplies the anterior two-thirds of the tongue. Posterior taste buds have information carried via the glossopharyngeal nerve. Taste information from the palate is carried by the greater superficial petrosal branch of the facial nerve, and, taste from the pharynx and larynx is supplied by the glossopharyngeal and vagus nerves. Primary taste afferents then project to the nucleus of the solitary tract in the medulla before passing to the thalamus and gustatory cortex. As with the nose, nociceptive afferents of the trigeminal nerve supply the oral cavity.

The mandibular nerve exits the cranium from the foramen ovale and enters the mandible on the internal aspect of the ramus below the lingula. The lingual nerve branches just after exiting the skull and courses superficially along the lingual plate of the mandible in the region of the third molar. The chorda tympani branch of the facial nerve joins the lingual nerve as it courses the lingual plate and enters the tongue. The chorda tympani nerve also supplies parasympathetic fibers to the submandibular and sublingual glands. Injury to these nerves may occur at
several stages during orthognathic surgery. The nerve may be stretched, avulsed, or cut during dissection, torn during mobilization of segments, or injured during stabilization.¹⁰

A common complication of bilateral sagittal split ramus osteotomy is paresthesia caused by injury to the inferior alveolar or lingual and chorda tympani nerves. Incidence of nerve injury has been reported to be from 3.5%⁵ to 24%.²⁸

Alterations in taste sensitivity have been reported resulting from chorda tympani stretching in patients who had undergone ossicular reconstruction.¹⁹ Altered taste functions have also been seen in patients with middle ear disease¹ and in rats following chorda tympani transection.²⁶ Damage to salivary gland fibers may impair gustation by decreasing salivary flow.

Damage to the inferior alveolar nerve generally manifests as a hypoesthesia around the lower lip/mentalis region of the affected side. Paresthesias lasting longer than six months are generally considered permanent. Resolution within six months is attributed to nerve regeneration, collateral innervation or both.¹⁰

Lingual and chorda tympani nerve damage is less common and shows variation. Etiology seems to be related to its close proximity to the lingual plate of the mandible.¹⁰ Long fixation screws may impinge upon the nerve in this area. Also, its close proximity to third molars puts the nerve at risk during third molar extractions¹⁶. Finally, a lingual nerve that courses buccally may be compromised during soft tissue dissection.²⁴ Paresthesia of the tongue is an indication of lingual nerve impairment.
Taste loss in the anterior two-thirds of the tongue and xerostomia are indications of chorda tympani damage.

Taste information from the palate is carried by the greater superficial petrosal branch of the facial nerve. This nerve enters the palate posteriorly through the palatine foramina. While attempts are made to protect structures passing through these foramina, it is possible that separation of the posterior maxilla from the cranium may compromise these nerves and vessels.

In the present study, it is hypothesized that orthognathic surgery will adversely affect olfactory and gustatory function.

**Objectives**

A complication of any surgical procedure is injury to the involved hard and soft tissues intraoperatively or during recovery. Orthognathic surgical procedures are performed in areas where chemosensory structures are found. The present study will evaluate a) whether orthognathic surgery alters chemosensory function, b) the type, severity and time course of any chemosensory changes.
METHODS

Subjects
Subjects were drawn from those presenting to the University of Connecticut School of Dental Medicine, Department of Oral and Maxillofacial Surgery for orthognathic surgery. Those with previous maxillofacial surgery or recent head trauma were excluded. Five patients participated in the study. They were between the ages of 18 and 36, with an average age of 23. Four were female and one was male.

Subject data
For each subject, a diagnostic and surgical survey was completed. The diagnostic survey was of interview format and was conducted before each chemosensory evaluation. Information obtained included subjective assessment of taste and smell function, location and time course of any dysfunction and potential causes of dysfunction. A medical history was completed as well.

The surgical survey was completed with the oral surgeon from preoperative, intraoperative, and postoperative notes. Information included skeletal and dental diagnosis, the surgical movements of both jaws in three planes of space, the type of fixation, pathologic or other surgical findings, and complications.

Orthognathic surgery
The surgeries consisted of a combination of one and two jaw procedures, with all patients having mandibular osteotomies. Individual jaw movements varied in accordance with the patients' functional and esthetic needs and are summarized in Table 1.
Chemosensory tests and measurements

Testing was performed in a quiet testing room, with the patient at ease, in an unhurried atmosphere. Testing was conducted by one of two operators who received the same training in administration of the test. Each session lasted approximately one hour.

Chemosensory testing was conducted within 2 weeks pre-op, 2 months post-op, and 6 months post-op. Two month and six month post-op times were chosen because the duration of dysgeusia following chorda tympani loss in patients who had undergone stapedectomy was shown to range from one week to nine months, with an average of three to four months. Additionally, inflammation and swelling should be completely subsided by 6 months. Long-term evaluation will be conducted at 12 and 24 months.

Taste

The gustation tests used at the Connecticut Chemosensory Clinical Research Center (CCCRC) were developed at the CCCRC by Dr. Linda Bartoshuk, presently at the Section of Otolaryngology at Yale University.

Whole Mouth Test

The whole mouth test is a magnitude matching suprathreshold test designed to evaluate taste sensation in the oral cavity as a whole. Taste samples ranged from water to very strong concentrations of bitter, sour, sweet, and salty tastants.
Two sets of 26 different tastes were used:
- 5 concentrations of NaCl (salty): .01M, .032M, .1M, .32M, 1.0M
- 5 concentrations of sucrose (sweet): .01M, .32M, .1M, .32M, 1.0M
- 5 concentrations of citric acid (sour): .00032M, .0032M, .001M, .032M, .01M
- 4 concentrations of 6-n-propyl-2-thiouracil (bitter): .000056M, .00056M, .00018M, .0018M
- 6 concentrations of quinine monohydrochloride (bitter): .00000032M, .000001M, .000032M, .0001M, .00032M, .001M
- 1 deionized water

Ten ml samples of each tastant were provided in small serving cups and delivered randomly to the patient (except .1M NaCl was always given first). Sample order was randomized for each patient.

With each sample, the subject was asked to swish for several seconds then spit the sample out in a sink. They were then asked to rate the concentration of the sample on a prearranged scale chosen by the subject. Between each sample, the patient was provided deionized water with which to rinse. This was done with 26 different tastants, then repeated with a newly randomized set of the same tastants.

Between every fourth taste, the subject was asked to rate tones of varying intensities delivered via earphones (range 50-90 DB) on the same scale. Because different people rate intensity (of any kind of stimulus) on different scales, the tone data acts as a normalization factor so that comparisons can be made between groups.

All values were recorded from the two trials and a mean was taken for each concentration sample. The mean was then multiplied by a normalization factor derived from the tone data. Patient data could then be compared to a table of previously determined norms for each taste quality, and a percentile score generated.
**Spatial Taste Test**

The spatial taste test examines regional taste function. In this test, the patient was presented a stimulus to the right and left anterior lateral tongue, posterior tongue and palate, and was then asked to identify the taste and rate its intensity using a 1 to 9 scale (1 being weakest). The tastants were applied to these six regions of the oral cavity using a Q-tip soaked in the strongest concentration (see above) of each tastant. Taste sensation was also evaluated during swallowing by having the patient project or "throw" the sample from a small cup to the back of the throat, attempting to by-pass the other taste areas. The samples were hidden behind a barrier out of subject view to prevent influencing the responses. Between each sample, the patient was instructed to swish with deionized water. Responses were then compared to normative data by deriving percentile scores for each tastant at each sensory area.

**Smell**

The olfactory test used at the CCCRC is a reliable, well-validated butanol threshold/odor identification test developed by Dr. William S. Cain. It is composed of two parts: one is a forced choice butanol test measuring threshold detection, the other is an odor identification test measuring an individual's ability to distinguish between different odorants. When comparing a group of 441 patients with olfactory complaints and 229 normal controls, both tests readily distinguish between patients and controls. In cases of transantral ethmoidectomy for ethmoid sinus disease, the test has been shown to document postoperative changes in olfactory acuity.
**Butanol Threshold**

Eleven concentrations of butanol are prepared and placed in squeeze bottles. The highest concentration is a 4% aqueous solution; each subsequent sample is three times more dilute than the previous sample.

Samples are labelled 1 - 11 (1 being the strongest concentration, 6-7 being about average, and 11 being the weakest concentration). For each trial, the patient was presented two squeeze bottles, one containing a butanol sample and one containing non-odorous deionized water. Each subject began with sample #9, considered to be slightly below normal threshold strength. With one nostril closed, each bottle was held close to the open nostril and squeezed while the odor was inhaled. A forced choice was made identifying the odorant bottle. If a misidentification occurred, the next higher concentration was used. A threshold was considered reached when a sample at the same concentration was identified correctly five consecutive times for that nostril. This value was then recorded for comparison to a normative population.

**Odor Identification**

In the odor identification test, the subject was asked to identify a particular common odor. Odors were presented in a cup with the contents visually screened from the patient. The sample was then tested with one nostril and identified using a list of twelve possible odorants as a reference. The odorants included seven olfactory and one trigeminal stimulus:

<table>
<thead>
<tr>
<th>Olfactory stimulants</th>
<th>Trigeminal stimulant</th>
</tr>
</thead>
<tbody>
<tr>
<td>baby powder</td>
<td>mothballs</td>
</tr>
<tr>
<td>chocolate</td>
<td>peanut butter</td>
</tr>
<tr>
<td>cinnamon</td>
<td>ivory soap</td>
</tr>
<tr>
<td>coffee</td>
<td>Vicks</td>
</tr>
</tbody>
</table>
Two trials were given to correctly identify the odor. If an incorrect choice was made on the first attempt, the subject was told the correct odor and another chance given during the second trial. The total number of olfactory odorants correctly identified were then summated for an odor identification score. The trigeminal scores were not used in data computation.

**Data Analysis**

For all analysis, significance was set at p< .05.

Pre-operative whole mouth taste scores were compared to the two and six month post-operative scores using two-tailed paired T-tests. Individual taste qualities were analyzed as were overall taste scores.

Spatial taste data was evaluated by identifying the number of specific areas of total taste loss, defined as no response to the highest concentration of a tastant at a given area. Changes in the frequency of aguesic areas were analyzed using Fisher's Exact Test.

Olfactory threshold and identification was analyzed for both right and left nostrils using two-tailed paired T-tests. Composite scores, generated by combining the butanol threshold score with the odor identification score, were analyzed similarly. The design of the olfactory test prevented evaluation of possible improved olfactory function. The highest value for the test is considered to be representative of normal olfactory ability. Subjects testing normosmic preoperatively can not be evaluated for improvements. To detect deficits in olfaction, a 40% reduction in olfactory scores was needed for statistical significance.
RESULTS

Olfaction

An olfactory composite score was generated by combining the butanol threshold score with the odor identification score. Composite scores at two months post surgery showed no significant difference from pre-surgical scores using two-tailed t-tests (Table 2). Similar results were found at six months following orthognathic surgery when compared to pre-surgical scores (Fig 3, Table 3).

Independently, the butanol threshold and odor identification scores showed no significant difference from pre-surgical to post-surgical values. When separating left and right nostrils, again, no significant differences were found (Table 2 & 3).

Gustation

Whole Mouth:

Whole mouth test scores for individual taste qualities (salty, sweet, bitter, sour) decreased significantly for three of the four tastants at two months following surgery (Fig. 4, Table 4, Table 6). Using paired, two-tailed t-Tests, significant decreases were found for salt scores, \( p = .027 \), sweet scores, \( p = .041 \), and sour scores, \( p = .042 \). Bitter scores were not significant at \( p = .318 \). When all tastants are combined for an overall whole mouth taste score, the decrease two months following surgery is just beyond statistical significance, \( p = .075 \).
Six months following orthognathic surgery, whole mouth scores varied. Two subjects had scores that exceeded their presurgical values, while two remained unchanged from their two month postoperative values. One subject was lost from the study at the six month evaluation. This subject was dropped from analysis when evaluating preoperative and six month postoperative data. None of the individual quality scores were significantly different from pre-surgical values (Table 5).

**Spatial Taste Test:**

Spatial taste data was evaluated by identifying the number of specific areas of total taste loss. Using Fisher's Exact test, a significant increase in the number of areas with total taste loss were seen two months following surgery for salt and sour tastants (p = .042 and p = .006, respectively). Increases in the number of affected areas for bitter (p = .094) and sweet (p = .067) were not significant. When all taste qualities are combined, the increase in areas of total taste loss is highly significant, p < .001 (Table 7).

Six months following surgery, significant increases in affected areas from preoperative values was seen for salt (p = .016), sour (p = .035), and bitter (p = .020). Overall spatial taste loss six months after surgery is highly significant at p < .001 (Table 8).
Chemosensory Interview:

There were no subjective reports of altered taste or smell function following surgery. Altered perceptions of the individual taste qualities were also not reported. Subjects denied any changes in eating habits or any perceptible changes in salivary flow. All subjects reported post-operative swelling that they felt had subsided by the first post-operative chemosensory evaluation. Two subjects reported post-operative facial numbness in the tongue and lower lip/mentalis region. By the six month evaluation the numbness was considerably less but still present. The location of spatial taste loss in these patients was consistent with the location of sensory loss. One patient reported excessive pain in the region of the both temporomandibular joints two months following surgery. By six months the pain had lessened.
DISCUSSION

The whole mouth taste test evaluates an individual's ability to detect, distinguish between, and rate by intensity four primary taste qualities: salty, sweet, sour, and bitter. Regardless of the type of surgical procedure, all subjects showed measurable decreases in whole mouth scores two months following surgery. Significant decreases were observed for the salt, sweet and sour taste qualities, while the ability to detect bitter tastants seemed to be preserved.

Whole mouth testing six months following surgery revealed a tendency to return to preoperative values. Two of the subjects scored slightly above the presurgical values, while two remained near the two month postoperative values. One subject was lost for the six month evaluation and was excluded from data analysis. When comparing whole mouth scores presurgically and six months postsurgically, there were no significant differences for any of the taste qualities. But because two of the patients six month scores changed very little from the two month scores, continued follow up will be necessary to further evaluate the time course of the dysfunction.

Spatial taste data was evaluated by identifying the number of specific areas of total taste loss. Two months following surgery, significant spatial taste loss was observed for all the tastants taken as a group. Individually, the salt and sour tastants showed significant spatial losses.
Testing four months later revealed significant losses for the same tastants plus the addition of bitter as an additional lost quality.

The patterns of spatial taste loss generally paralleled regions innervated by particular nerves. The two patients that reported unilateral numbness in the tongue and lower lip/mentalis region following surgery also had total taste losses on the same side of the tongue. This suggests that the inferior alveolar, lingual, and chorda tympani nerves were compromised in some way during the surgery, the fixation, or during healing.

Total, or nearly total taste loss in the palate, was seen in two of three patients having undergone maxillary surgery. There were no signs of nerve damage reported by the surgeon as a result of the surgical or fixation procedure in either jaw.

It was predicted that if there were any alterations in gustatory function, it would most likely be spatial due to frequent reports of numbness following orthognathic procedures. While losses in spatial function were found, it was not expected that spatial deficits were sufficient to decrease whole mouth function as was seen in the present study.

Regardless of the measurable decreases in gustatory function, subjects in this study did not report taste loss at the time of testing. None reported taste impairments for the four taste qualities individually and eating habits remained the same. Even the subject who had a 90% drop in
whole mouth scores did not report a change in gustatory sensitivity.

Orthognathic surgery did not alter olfactory function in the present study. Previous reports showed that Le Forte I impaction procedures decrease airway resistance by influencing the shape of the nasal passage.\textsuperscript{17,27} It was hypothesized that an altered shape to the nasal passage, either by a change in the shape of the external nares or a change in the shape of the internal architecture of the nose as a result of maxillary repositioning, might influence the ability of odorant molecules to come in contact with the olfactory epithelium, thereby altering olfaction. However, the design of the olfactory test in this study prevented evaluation of improvements in olfactory ability in those starting with the highest value (considered normosmic). Therefore, there may have been improvements in olfaction that were not detected. There was also no reason to suspect that other olfactory structures, such as the cribriform plate, were damaged during the surgical procedures.

**Conclusion**

Preliminary findings in this study have suggested that orthognathic surgical procedures (Le Forte I, BSSRO, or both) can have an impact on gustatory acuity when measured objectively. While all basic taste qualities can be detected throughout the mouth, spatial losses were sufficient to decrease whole mouth function. However, despite the objective losses, subjects did not report deficits in taste function. Olfactory function, as measured in this study, did not differ significantly following orthognathic surgery.
REFERENCES


Fig. 1. Le Forte I osteotomy.
Sectioning of nasal septum with osteotome.

Fig. 2. Bilateral sagittal split ramus osteotomy.
Fig. 3. Olfactory composite scores; pre-surgery, 2 months post-surgery, and 6
Fig. 4. Whole mouth taste percentiles; pre-surgery, 2 months post-surgery, and 6 months post-surgery
Table 1. Summary of orthognathic procedures.

<table>
<thead>
<tr>
<th>Case</th>
<th>Maxilla</th>
<th>Mandible</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Le Forte I</td>
<td>BSSRO</td>
</tr>
<tr>
<td></td>
<td>-Impaction</td>
<td>-Setback</td>
</tr>
<tr>
<td>2</td>
<td>No surgery</td>
<td>BSSRO</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Advancement</td>
</tr>
<tr>
<td>3</td>
<td>Le Forte I</td>
<td>BSSRO</td>
</tr>
<tr>
<td></td>
<td>-Downfracture</td>
<td>-Setback</td>
</tr>
<tr>
<td></td>
<td>-Setback</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>No Surgery</td>
<td>BSSRO</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Setback</td>
</tr>
<tr>
<td>5</td>
<td>Le Forte I</td>
<td>BSSRO</td>
</tr>
<tr>
<td></td>
<td>-Impaction</td>
<td>-Advancement</td>
</tr>
</tbody>
</table>
Table 2. Olfactory scores on five patients undergoing orthognathic surgery, Presurgical and two month postsurgical scores.

<table>
<thead>
<tr>
<th>Case</th>
<th>Butanol threshold</th>
<th>Odor identification</th>
<th>Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right Pre</td>
<td>Post</td>
<td>Left Pre</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Mean</td>
<td>6.2</td>
<td>7</td>
<td>6.2</td>
</tr>
<tr>
<td>Diff.</td>
<td>.8</td>
<td>.2</td>
<td>.2</td>
</tr>
</tbody>
</table>

No significant mean differences.

Table 3. Olfactory scores on four patients undergoing orthognathic surgery, Presurgical and six month postsurgical scores.

<table>
<thead>
<tr>
<th>Case</th>
<th>Butanol threshold</th>
<th>Odor identification</th>
<th>Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right Pre</td>
<td>Post</td>
<td>Left Pre</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Mean</td>
<td>6</td>
<td>6.5</td>
<td>6</td>
</tr>
<tr>
<td>Diff.</td>
<td>.5</td>
<td>0</td>
<td>-.75</td>
</tr>
</tbody>
</table>

No significant mean differences.
Table 4. Whole mouth probability scores presurgical versus two months postsurgical (n=5).

<table>
<thead>
<tr>
<th></th>
<th>Presurgical</th>
<th>Postsurgical</th>
<th>Probability (2-tail)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>sd</td>
<td>mean</td>
</tr>
<tr>
<td>Salt</td>
<td>63.2</td>
<td>27.2</td>
<td>26.6</td>
</tr>
<tr>
<td>Sweet</td>
<td>78.4</td>
<td>19.1</td>
<td>46.6</td>
</tr>
<tr>
<td>Sour</td>
<td>57.2</td>
<td>29.5</td>
<td>31.6</td>
</tr>
<tr>
<td>Bitter</td>
<td>65.8</td>
<td>17.7</td>
<td>50.0</td>
</tr>
<tr>
<td>Overall</td>
<td>66.6</td>
<td>26.9</td>
<td>37.4</td>
</tr>
</tbody>
</table>

Paired t-Test

Table 5. Whole mouth probability scores presurgical versus six months postsurgical (n=4).

<table>
<thead>
<tr>
<th></th>
<th>Presurgical</th>
<th>Postsurgical</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>sd</td>
<td>mean</td>
</tr>
<tr>
<td>Salt</td>
<td>63.2</td>
<td>27.2</td>
<td>36.3</td>
</tr>
<tr>
<td>Sweet</td>
<td>78.4</td>
<td>19.1</td>
<td>46.0</td>
</tr>
<tr>
<td>Sour</td>
<td>57.2</td>
<td>29.5</td>
<td>40.3</td>
</tr>
<tr>
<td>Bitter</td>
<td>65.8</td>
<td>17.7</td>
<td>56.8</td>
</tr>
<tr>
<td>Overall</td>
<td>66.6</td>
<td>26.9</td>
<td>44.0</td>
</tr>
</tbody>
</table>

Paired t-Test
Table 6. Whole mouth scores for individual taste qualities.

<table>
<thead>
<tr>
<th>Case</th>
<th>Presurgical</th>
<th>2 mo. post-surgical</th>
<th>6 mo. post-surgical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SALTY</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>43</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>2</td>
<td>84</td>
<td>76</td>
<td>*</td>
</tr>
<tr>
<td>3</td>
<td>76</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>87</td>
<td>37</td>
<td>92</td>
</tr>
<tr>
<td>5</td>
<td>26</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td><strong>SWEET</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>58</td>
<td>38</td>
<td>41</td>
</tr>
<tr>
<td>2</td>
<td>92</td>
<td>88</td>
<td>*</td>
</tr>
<tr>
<td>3</td>
<td>93</td>
<td>24</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>92</td>
<td>74</td>
<td>95</td>
</tr>
<tr>
<td>5</td>
<td>57</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td><strong>SOUR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>47</td>
<td>28</td>
<td>44</td>
</tr>
<tr>
<td>2</td>
<td>73</td>
<td>71</td>
<td>*</td>
</tr>
<tr>
<td>3</td>
<td>62</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>91</td>
<td>57</td>
<td>91</td>
</tr>
<tr>
<td>5</td>
<td>13</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td><strong>BITTER</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>46</td>
<td>36</td>
<td>81</td>
</tr>
<tr>
<td>2</td>
<td>58</td>
<td>48</td>
<td>*</td>
</tr>
<tr>
<td>3</td>
<td>76</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>91</td>
<td>85</td>
<td>92</td>
</tr>
<tr>
<td>5</td>
<td>58</td>
<td>65</td>
<td>48</td>
</tr>
</tbody>
</table>

* Not available
Table 7. Spatial taste test. Number of affected areas (areas of total taste loss) presurgical versus two month postsurgical.

<table>
<thead>
<tr>
<th>Quality</th>
<th>Presurgical</th>
<th>Postsurgical</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt</td>
<td>Affected</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Not Affected</td>
<td>33</td>
<td>27</td>
</tr>
<tr>
<td>Sweet</td>
<td>Affected</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Not Affected</td>
<td>31</td>
<td>25</td>
</tr>
<tr>
<td>Sour</td>
<td>Affected</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Not Affected</td>
<td>33</td>
<td>24</td>
</tr>
<tr>
<td>Bitter</td>
<td>Affected</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Not Affected</td>
<td>32</td>
<td>27</td>
</tr>
<tr>
<td>Overall</td>
<td>Affected</td>
<td>11</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>Not Affected</td>
<td>129</td>
<td>103</td>
</tr>
</tbody>
</table>

Fisher's Exact Test
Table 8. Spatial taste test. Number of affected areas (areas of total taste loss) presurgical versus six months postsurgical.

<table>
<thead>
<tr>
<th>Quality</th>
<th>Presurgical</th>
<th>Postsurgical</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt</td>
<td>Affected</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Not affected</td>
<td>33</td>
<td>20</td>
</tr>
<tr>
<td>Sweet</td>
<td>Affected</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Not affected</td>
<td>31</td>
<td>21</td>
</tr>
<tr>
<td>Sour</td>
<td>Affected</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Not affected</td>
<td>33</td>
<td>21</td>
</tr>
<tr>
<td>Bitter</td>
<td>Affected</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Not affected</td>
<td>32</td>
<td>19</td>
</tr>
<tr>
<td>Overall</td>
<td>Affected</td>
<td>11</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>Not affected</td>
<td>129</td>
<td>81</td>
</tr>
</tbody>
</table>

Fisher's Exact Test