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A prospective study on changes in the sensibility of the oral mucosa and the mucosa of the upper lip after Le Fort I osteotomy

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SUMMARY. **A prospective study on 21 patients was performed in order to investigate the changes in the sensibility of the oral mucosa and the mucosa of the upper lip after a Le Fort I osteotomy. Patients were followed-up 1 month, 3 months and 6 months postoperatively. The sensibility of the mucosa was tested using electrical sensimetry (Laitinen, 1987). The teeth were tested with carbon dioxide snow (*Obwegeser* and *Steinhäuser*, 1963). A picture of the marked hypoaesthetic area was performed and magnified 1:1 if a hypoaesthesia of the cutaneous distribution of the infraorbital nerve was found. The area was measured using a Macintosh II CX computer. It was demonstrated, that after 3 months the infraorbital nerve regained its function completely. The greater palatine nerve and the posterior superior alveolar nerve demonstrated an incomplete recovery of sensory function after 6 months. After 6 months 92.8% of the teeth reacted to carbon dioxide snow. Within the first 6 months postoperatively, no pulpe necrosis was observed. No correlation could be found between the amount of anterior maxillary movement and the degree of hypoaesthesia of the infraorbital nerve. Dentate Le Fort I osteotomies showed a better sensory regeneration of the greater palatine nerve than edentulous Le Fort I osteotomies. After Le Fort I osteotomies in 2 parts, more hypoaesthesia of the greater palatine nerve was observed than after Le Fort I osteotomies in 1 part. After miniplate osteosynthesis, more hypoaesthesia of the posterior superior alveolar nerve was observed than after wire osteosynthesis. The results are discussed and compared with the results found in the literature. Suggestions to decrease the postoperative hypoaesthesia of the nerves supplying the mucosa have been made.**

INTRODUCTION

Most of the osteotomy lines in the upper and lower jaw are in the immediate neighbourhood of peripheral branches of the maxillary and mandibular nerve. Many authors have done retrospective investigations on the regeneration of sensory nerves after sagittal split osteotomies, segmental osteotomies, genioplasties and Le Fort I osteotomies (*Pepersack*, 1973; *De Jongh* et al., 1986; *Lindquist* and *Obeid*, 1988; *Vedhofte* and *Nattestadt*, 1989). Most of these papers discuss the vitality of the teeth after a Le Fort I osteotomy. Only a few authors did prospective investigations. *Kohn* and *White* (1974) did a prospective study on the vitality of teeth after segmental osteotomies. *Yoshida* et al. (1989) conducted a prospective study on the function of the inferior alveolar nerve after sagittal split osteotomies. *Karas* et al. (1990) investigated the function of the infraorbital and mental nerves, but only the cutaneous parts of the areas were supplied. None of these authors conducted a prospective quantitative study of the tactile sense of the oral mucosa after Le Fort I osteotomy.

In cases of severe atrophy of the edentulous maxilla, a Le Fort I osteotomy is performed with simultaneous transplantation of autogenous pelvic bone and the placement of screw implants (*Braenemark* et al., 1983; *Braenemark* et al., 1985; *Sailer*, 1989). Osseointegration of the implants in the maxilla takes about 6 months. During this period, patients ought to have a temporary prosthesis which is inevitably borne by the mucosa. Uncontrolled chewing forces of the lower jaw on the hypoaesthetic maxilla may result in resorption of the interposed bone transplant and therefore endanger the survival rates of these screw implants.

For qualitative measurements of sensation, simple clinical methods such as temperature discrimination and sharp-blunt discrimination are available. For quantitative measurements, laboratory methods are known with which the tactile sense (*Dyck* et al., 1971; *Dyck* et al., 1976; *Goldberg* and *Lindblom* 1979) as well as the sense of pain (*Fruhstorfer* et al., 1976) can be tested. These methods, however, are time-consuming and unsuitable for daily clinical practice. The electrical measurement of sensory function is a good and reliable method for quantitative measurement of touch and pain and gives reproducible results (*Notermans*, 1966; *Notermans*, 1967; *Tursky* and *O'Connel*, 1972; *Harris* and *Rollman*, 1983; *Toolanen*, 1986). The measurement must be simple and should be suitable for use in daily practice (*Laitinen* and *Erikson*, 1985). The *Issal* sensometer is a portable electrical stimulator which produces rectangular monophasic pulses of 0.2 ms and a stimulus repetition of 100 Hz. The current is strictly constant within an impedance of 0 to 1.5 kOhm. The output is steplessly adjustable from 0 to 60 mAmp and readable with an accuracy of 0.1 mAmp. The bipolar electrode consists of saline-soaked felt discs with a surface of 1 cm^2 and an interpolar distance of 1 cm. The power is generated by

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a 9 volt rechargable battery. The pain threshold as well as the threshold for touch can be measured. The accuracy of the *Issal* sensometer is 0.1 mAmp. The standard deviation for measurement of touch is 0.5 mAmp (*Laitinen* and *Eriksson*, 1985; *Laitinen*, 1987, *Laitinen* et al., 1989).

Testing the sensation with carbon dioxide snow is possible on every tooth, especially the crowned tooth. It is a reliable method with a margin of error of 2.8% (*Obwegeser* and *Steinhäuser*, 1963).

In this prospective study we investigated the sensory function of the infraorbital nerve, greater palatine nerve, posterior superior alveolar nerve and the dental plexus after Le Fort I osteotomy. We attempted to obtain information on the sensory function 1 month, 3 months and 6 months postoperatively.

MATERIAL AND METHODS

From January 1992 to October 1992, 21 patients were included in a prospective study. In this period all 21 patients had a Le Fort I osteotomy. Patients with tumours such as haemangioma, lymphangioma or neurofibroma were excluded. Patients, who had already had a Le Fort I osteotomy in the past were excluded.

Besides the necessary preoperative preparations for the Le Fort I osteotomy the following neurological parameters were assessed:

- anamnestic hypoaesthesia of the infraorbital nerve.
- sensometer values of the infraorbital nerve in mAmp. The electrodes were placed exactly below the highest point of the vermilion border and on the mucosa of the upper lip (*Laitinen*, 1987).
- sensometer values of the greater palatine nerve in mAmp. The mesial electrode was placed 4 mm under the marginal gingiva of the first premolar and always distal to the area supplied by the incisive nerve.
- sensometer values of the posterior superior alveolar nerve. The electrodes were placed in the vestibulum distal to the cuspid
- vitality of all maxillary teeth using carbon dioxide snow (*Obwegeser* and *Steinhäuser*, 1963). All nonvital teeth were excluded preoperatively.

The above mentioned measurements were assessed again 1 month, 3 months, and 6 months postoperatively. The average sensometer values as well as the standard deviation were determined and compared with the preoperative sensometer values.

In 15 of the 18 cases of subjective hypoaesthesia of the cutaneous parts of the infraorbital nerve, a standardised photograph of the marked hypoaesthetic area was taken. Camera: Minolta: distance camera-object: 2 metres; filmtype 400 ASA. All pictures were taken by one person. The 1:1 magnification of the photographs was done using the lateral cephalogram as a standard. The measurement of the marked area of the photograph was done using computer analysis. The photographs were digitalized in an Agfa scanner (type 800 GS). The digitalized pictures were processed using a picture process program Image 1.28 in a Macintosh II CX computer. The two dimensional projection of the three dimensional hypoaesthetic area was measured. The size of the hypoaesthetic area was compared with the amount of anterior movement of the maxilla.

RESULTS

The investigated sample of patients consisted of 13 women and 8 men. Mean age 27.11 years; min 17 years; max 56 years. In this prospective study, 9 patients had a retropositioned maxilla and 4 patients had an open bite. Two other patients had an open bite with a long face. In 1 patient, an open bite with amelogenesis imperfecta existed. One other patient had an unilateral cleft-lip and palate with a cross bite in the premolar-molar region. Four patients had a retroposed maxilla due to edentulousness.

Operation

All 21 patients had a le Fort I osteotomy performed (*Obwegeser*, 1964; *Obwegeser*, 1965). In 2 patients, a Le Fort I osteotomy in 2 parts was performed. In one of these patients the palate was segmented paramedially on one side and anteriorly between the central incisors. The second patient had a previously closed unilateral cleft lip and palate. In 3 edentulous patients, a Le Fort I osteotomy with simultaneous insertion of screw implants was performed. In 1 edentulous patient, a Le Fort I osteotomy was performed without the implantation of screw implants (*Sailer*, 1989).

Other simultaneously performed interventions included 10 sagittal split osteotomies (*Trauner* and *Obwegeser*, 1955), 1 body step osteotomy (*Babcock*, 1909; *Pichler*, 1919; *Freihofer*, 1991; *Stoelinga* and *Leenen*, 1992), 4 genioplasties (*Obwegeser*, 1958), 1 segmental osteotomy of the lower jaw, 2 symphysectomies, 1 turbinectomy and 4 modified submucosal vestibuloplasties (*Obwegeser* and *Farmand*, 1984). Bone morphogenetic protein (BMP) was applied in 2 patients (*Kolb* and *Sailer*, 1992).

In 16 patients, autologous bone was interposed in the site of the osteotomy. In 1 patient lyophilised bone was used in combination with BMP paste. In 5 other patients it was not necessary to insert a bone graft.

The average anterior maxillary movement in dentate Le Fort I osteotomies was 3.3 mm (min: 0 mm; max: 10 mm) (Fig. 1). In edentulous cases, the average amount of anterior movement was greater because of the more pronounced retroposition of the maxilla 8.3 mm (min 7, max 10 mm). After mobilization of the maxilla osteosynthesis was performed 15 times with wires, 6 times with miniplates. Titanium miniplates were used in 5 patients (Leibinger GmbH, Freiburg, Germany). Microplates were applied in one patient (Stratec, Waldenburg, Switzerland).

Complications

In this group of patients there were no major complications. In 2 cases, a haematoma developed,

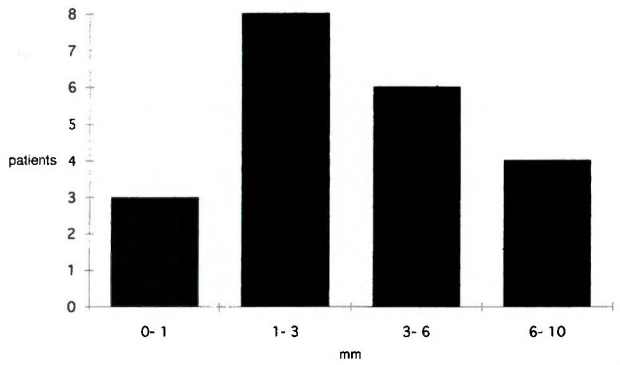


Fig. 1–Amount of anterior maxillary movement (n = 21 patients).

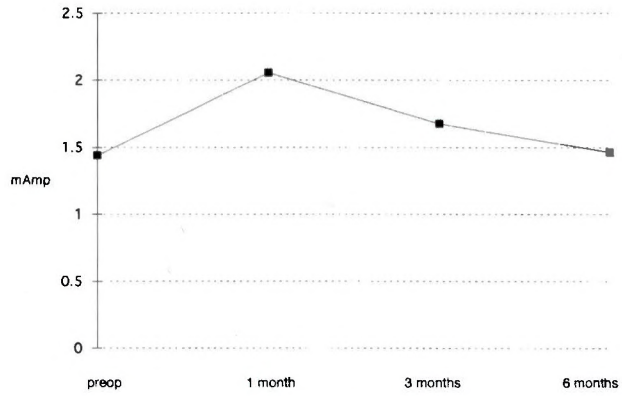


Fig. 2–Sensation of the infraorbital nerve.

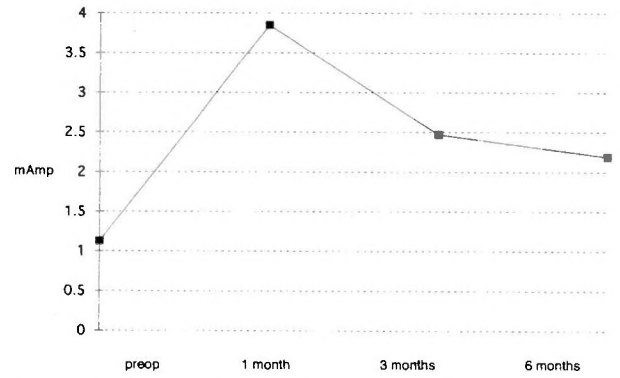


Fig. 3–Sensation of the posterior superior alveolar nerve.

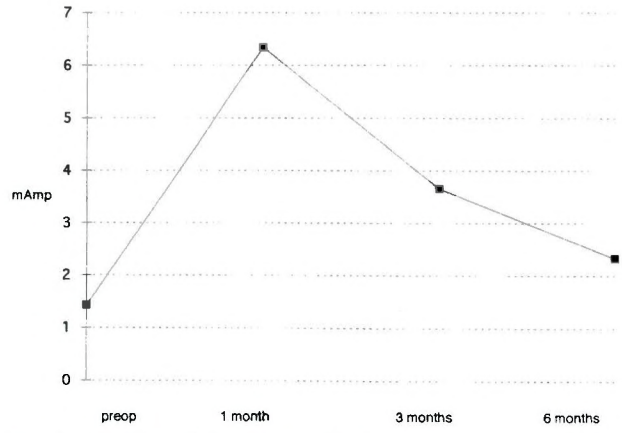


Fig. 4–Sensation of the greater palatal nerve.

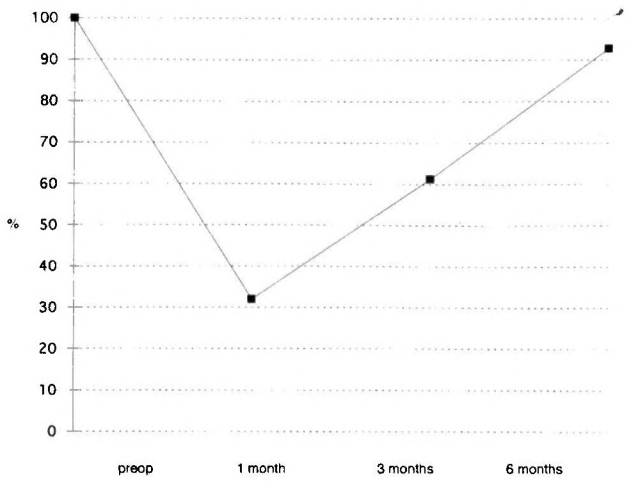


Fig. 5–Percentage of teeth non-reacting to carbon dioxide snow (n = 222).

which in 1 case was due to preoperative aspirin abuse. In 1 patient, a more profound swelling of the soft tissues was noticed. In 1 patient, a wound dehiscence was treated conservatively. In 1 edentulous patient, the greater palatine nerve had to be freed out of its bony canal, after which an incomplete fracture through the maxillary tuberosity was completed. In 1 patient, a persistent reduction of the opening of the mouth had to be treated for 3 months postoperatively by forced opening under general anaesthesia. No difference was found in the degree of hypoaesthesia of the infraorbital nerve, greater palatine nerve or posterior superior alveolar nerve in patients with and without complications.

The upper lip, upper vestibule and palate

Preoperatively, all 21 patients claimed to have a normal sensation in the infraorbital nerve area. One month postoperatively, 18 patients had an hypoaesthesia of the area supplied by the infraorbital nerve. One patient complained about hypoaesthesia of the palate; none of the patients complained of hypoaesthesia in the area of the posterior superior alveolar nerve.

In Figures 2, 3 and 4 the sensometer readings from the upper lip, upper part of the vestibule and the palate are shown. On the horizontal axis the time is lined. On the horizontal axis the time is lined. On the vertical axis the results of the sensometer are shown in mAmp. The highest degree of hypoaesthesia is found for all nerves investigated one month postoperatively.

In Figure 2, the results with respect to the infraorbital nerve are demonstrated. Three months postoperatively the sensory function has almost returned to the preoperative values and 6 months postoperatively the preoperative values are attained. The greater palatine nerve and the posterior superior alveolar nerve demonstrate an incomplete recovery of sensory function (Figs 3 and 4). Also, the difference between preoperative values and the values 1 month postoperatively is greater for the posterior superior

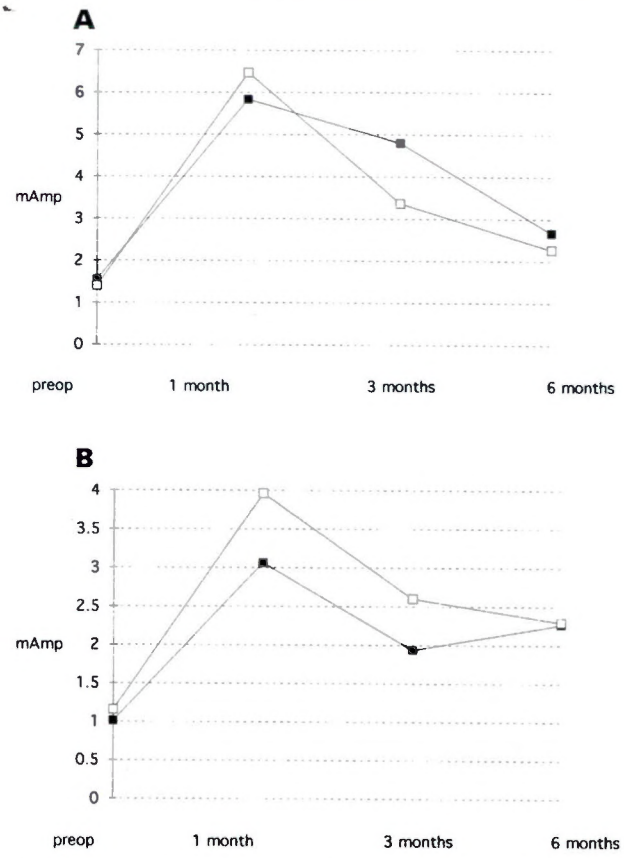


Fig. 6 – (A) Comparison between the sensation of the greater palatine nerve in edentulous and dentate patients. (B) Comparison of sensation of the posterior superior alveolar nerve in edentulous and dentate patients. ■: edentulous, □: dentate.

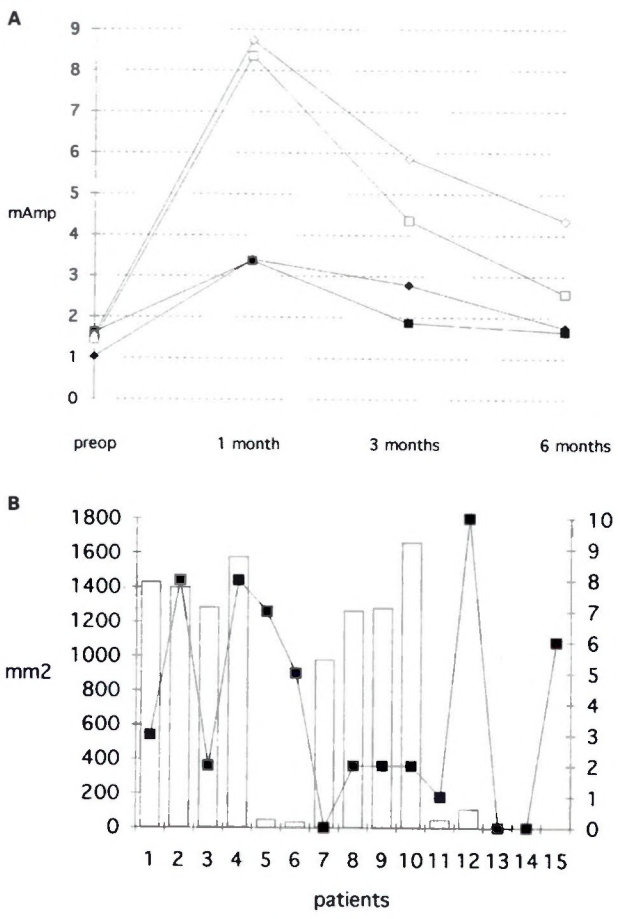


Fig. 7 – (A) Influence of the amount of anterior maxillary movement on greater palatine nere function. ■: 0–1 mm; □: 1–3 mm; ◆: 3–6 mm; ◇: 6–10 m. (B) Comparison between the amount of anterior maxillary movement and extent of hypoaesthetic area of the infraorbital nerve. □: hypoaesthesia mm2; ■: anterior movement.

alveolar nerve and the greater palatine nerve, than for the infraorbital nerve.

The teeth

Preoperatively, the vitality of all teeth were tested. 222 (100%) teeth reacted positively to carbon dioxide snow and were followed up for 6 months. Figure 5 gives a summary of the findings: 1 month postoperatively 32%, 3 months postoperatively 61.3% and 6 months postoperatively 92.8% reacted positively. During 6 months of observation, no colour changes in the teeth were noticed. No necrosis of the pulps of the maxillary teeth was found.

Comparison of Le Fort I osteotomies of the edentulous and the dentate jaw in regard to the greater palatine nerve and the posterior superior alveolar nerve

The curves are basically rather similar (Figs 6A, B), although it seems that return of sensation progresses more rapidly in dentate patients. This tendency appears more pronounced in the greater palatine nerve, than in the posterior superior alveolar nerve. These nerves appear to have not yet completely recovered after 6 months.

Comparison of the hypoaesthesia of the infraorbital nerve, greater palatine nerve and posterior superior alveolar nerve in patients younger and older than 40 years

Two groups were studied: younger than 40 years (n = 16), older than 40 years (n = 5). There were no major differences in any nerve after 6 months; after 1 and 3 months some minor differences were found, but all differences were within the standard deviation.

Influence of the amount of anterior maxillary movement and the regeneration of the function of the greater palatine and infraorbital nerve

In Figure 7A the amount of anterior maxillary movement is plotted against the amount of hypoaesthesia. The patient sample was divided into 4 groups: 0 to 1 mm of horizontal movement (3 patients, mainly vertical movement of several millimetres), 1 to 3 mm (8 patients), 3 to 6 mm (6 patients), 6 to 10 mm (4 patients).

The patients in the groups of 6 to 10 mm and 1 to 3 mm anterior maxillary movement had the greatest amount of hypoaesthesia of the greater palatine nerve.

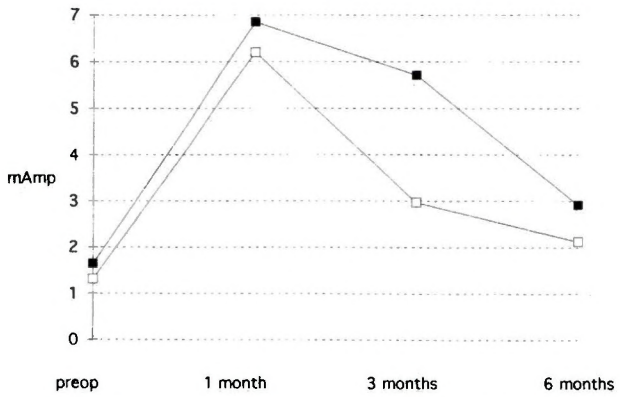


Fig. 8–Comparison of the Le Fort I osteotomy in one and two parts on greater palatine nerve function. ■: 2 parts; □: 1 part.

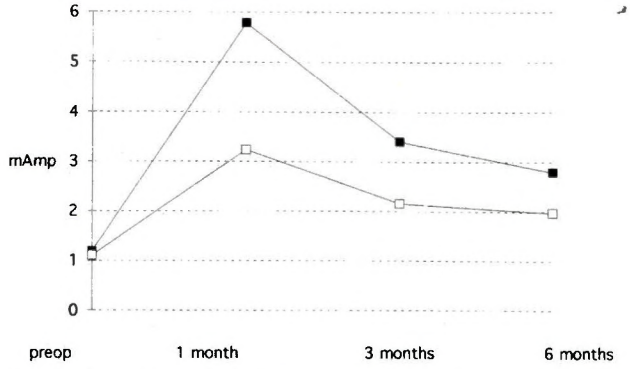


Fig. 9–Comparison of the influence on the posterior superior alveolar nerve of osteosynthesis with miniplates and wires. ■: miniplates; □: wires.

As is shown in Figure 7A the regeneration of the function of the greater palatine nerve is less if the amount of anterior maxillary movement is more than 6 mm. Six months values 6 to 10 mm 4.35 mAmp; compared with 3 to 6 mm: 1.75 mAmp, 1 to 3 mm: 2.57 mAmp, 0 to 1 mm: 1.65 mAmp.

The amount of anterior maxillary movement was compared with the two dimensional projection of a three dimensional marked hypoaesthetic area, supplied by the infraorbital nerve. No hypoaesthesia was found 3 and 6 months postoperatively. The hypoaesthesia was measured in 15 patients. The hypoaesthetic area measured 1 month postoperatively between 1576.23 and 0 mm^2. No correlation could be found between the size of the hypoaesthetic area and the amount of anterior maxillary movement (Fig. 7B).

Comparison of the sensibility of the palatal mucosa after Le Fort I osteotomy in one or two parts

In Figure 8, the evolution of the hypoaesthesia of the greater palatine nerve after Le Fort I osteotomy in 1 and 2 parts has been compared. The end results after 6 months are 2.12 vs 2.92 mAmp which is more than the standard deviation of 0.5 mAmp, but less than two times the standard deviation. So a statistically significant difference between these two types of Le Fort I osteotomy could not be observed, although it seems that recovery in the one part cases occurred earlier.

Comparison between the sensory function of the posterior superior alveolar nerve after osteosynthesis with miniplates and wire

Figure 9 compares the hypoaesthesia of the posterior superior alveolar nerve after osteosynthesis with miniplates and wires. The preoperative values do not differ much: miniplates 1.19 mAmp, wires 1.11 mAmp. 1 month, 3 months and 6 months postoperative values demonstrate less hypoaesthesia in cases of wire osteosynthesis; The difference in the 6 month values is still out of the standard deviation range. Osteosynthesis with wires after Le Fort I osteotomy gives less hypoaesthesia than osteosynthesis with miniplates, at least within this time span.

DISCUSSION

In the literature, many types of non-electrical (*Dyck* et al., 1971; *Dyck* et al., 1974; *Dyck* et al., 1976; *Fruhstorfer* et al., 1976; *Goldberg* and *Lindblom*, 1979) and electrical methods (*Notermans*, 1966; *Notermans*, 1967; *Tursky* and *O'Connel*, 1972; *Harris* and *Rollmann*, 1983) for testing the sensory function of peripheral nerves have been mentioned. Most of these methods are time-consuming.

Electrical testing of peripheral sensory nerves is a precise method with reproduciable results (*Notermans*, 1966; *Notermans*, 1967). Notermans (1966) was probably the first to use electrical stimulation in clinical practice. He used a square wave current. The frequency could be varied from 0.5 to 1500 Hz and the impulse duration range varied from 0.01 msec to 100 msec. The stimulating current was immediately readable and could be varied from 0 to 8 mAmp. Most reproducible results were found between 30 and 200 pulses per sec. From a practical point of view *Notermans* used frequencies of 50 and 100 Hz. As the indication for electrical measurement of sensation, *Notermans* mentioned differentiation between anaesthesia and hypoalgesia and control of therapy, for example, after neurosurgical interventions. *Tursky* and *O'Connel* (1972) used electrical stimulation from a 60 Hz constant current stimulator capable of delivering up to 21.0 mAmp in 0.1 mAmp steps. Skin impedance was lowered to 5000 Ohm by rubbing a saline paste on the skin. Excellent reliability and predictability of the suprathreshold levels was found. They concluded that the testing of sensation with electrical stimulation is a reliable method. *Harris* and *Rollmann* (1983) used an electrical stimulator with a constant current and monophasic square wave impulses at 100 Hz. Stimulation could be increased in steps of 0.15 mAmp; upper limit 7.5 mAmp. The electrical stimulators mentioned were complicated, which is the main reason that testing by electrical stimulation never became very popular.

The *Issal* sensometer, as opposed to the above mentioned stimulators, is a portable constant current electrical stimulator. The main difference with the above mentioned electrical methods is that the current is strictly constant within an impedance range of 0 to

1.5 KOhm and therefore independent of the inevitable variations in skin impedance. One does not need to rub the skin with saline paste. Only the application of the eletrodes, drained in physiological saline, is enough to lower the skin resistance. The method was tested in different clinical situations and found reliable (*Laitinen* and *Eriksson* 1985; *Toolanen*, 1986; *Bergenheim* et al., 1991).

For the classification of lesions of peripheral nerves, the classification of *Seddon* (1943) or *Sunderland* (1951) is generally accepted in the neurological literature. The latter is actually an expansion of *Seddon's* classification. *Seddon's* classification comprises:

1. Neuropraxia (*Sunderland* type 1): no nerve lesion only a temporary conduction block of several hours to months.
2. Axonotmesis (*Sunderland* type 2 and 3): lesion of the axons with intact endoneurium and perineurium. The distal part of the nerve will demonstrate a *Wallerian* degeneration.
3. Neurotmesis (*Sunderland* type 4 and 5): which is the complete transection of the peripheral nerve. As further expansion of these classifications, *Mackinnon* and *Delton* (1988) mentioned type 6: the formation of a neuroma.

In Figure 2 it was demonstrated that the infraorbital nerve regained its function after 3 months. Therefore, this temporary hypoaesthesia must be classified as a neuropraxia (conduction block, type 1 in *Sunderland's* classification). The sensibility of the greater palatine nerve and superior posterior alveolar nerve was demonstated in Figures 3 and 4. Its sensory function is not complete 6 months postoperatively. There is probably a more permanent conduction problem. One can probably classify this conduction problem as an axonotmesis (type 3 in *Sunderlands's* classification).

From this prospective investigation, it is obvious that the greater palatine and posterior superior alveolar nerves are more in danger of persistent nerve damage, than the infraorbital nerve. These results are in contrast to two retrospectively performed investigations on the tactile response of the oral mucosa after Le Fort I osteotomies.

De Jongh et al. (1986) were the first to investigate the oral mucosa retrospectively, on average 13.8 months after Le Fort I osteotomies. They tested with a sharp instrument; 25% of the patients did not demonstrate any reaction to this probing, but 9% of the patients in the control group did not demonstrate any reaction on probing either. Anteriorly, the gingiva reacted better than distally. *Kahnberg* and *Engstrom* (1987) investigated the buccal mucosa with a sharp instrument and found an hypoaesthesia 2 months postoperatively, which normalised after 6 months. The explanation for the difference between these two investigations and our results might be that testing with sharp-blunt discrimination such as 2 point discrimination, is an imprecise method, well-suited for qualitive measurement of the sensation, but not for precise quantitative measurement (*Campbell* et al., 1987; *Karas* et al., 1990).

Many investigations on the vitality of teeth after segmental osteotomies, sagittal split osteotomies and Le Fort I osteotomies have already been performed: *Poswillo* (1972) compared the teeth after segmental osteotomies for correction of open bites in a primate model. The nerves of teeth after the osteotomy demonstrated fibrosis and loss of odontoblasts. After 6 months the teeth were vital but without a nerve supply. *Pepersack* (1973) investigated the vitality of teeth after segmental osteotomies in the upper and lower jaw done in the clinic for maxillo-facial surgery in Zürich. Two out of 588 dental nerves became necrotic postoperatively; 30% of the teeth did not react to carbon dioxide snow, but were vital. Most of the non-reacting teeth were found in the neighbourhood of the vertical osteotomy lines. *Perko* (1972) demonstrated in 121 patients that most teeth, approximately 3 months postoperatively, reacted positively to carbon dioxide snow. *Kohn* and *White* (1974) evaluated teeth after segmental osteotomies. 28 of 189 teeth did not react to electrical stimulation. Five of 189 teeth had to be treated endodontically. *Tajima* (1975) performed a longitudinal study on teeth after Le Fort I osteotomies and Le Fort I fractures. Most teeth reacted for the first time to carbon dioxide snow 7 months postoperatively. The central and lateral incisors recovered later than the bicuspids and molars. *Vedhofte* and *Nattestad* (1989) investigated the reaction of the dental nerves of 51 patients. After 28 months, 617 teeth were investigated; 6% of the teeth did not react to electrical stimulation. Pulp necrosis was found in 0.5% (3 teeth). The amount of horizontal movement of the maxilla did not have any influence on the reaction of the teeth. Our results are slightly better than the ones mentioned above. In our sample, no necrosis of the dental nerves was found. The reason might be that in this investigation no segmental osteotomies were performed and therefore no pulp necrosis of the teeth near the vertical osteotomy lines was found. The second reason is that when fibrosis of the pulp occurs it only becomes a necrosis in the long-term.

The percentage of non-reacting teeth in our patients was 7.3% after 6 months, which is comparable with the results of *Vedhofte* and *Nattestad* (1989).

Major differences in the amount of hypoaesthesia between edentulous and dentate patients undergoing a Le Fort I osteotomy could not be found. But it seemed that, in edentulous cases, the regeneration of the nerve function is slower than in dentate individuals. Whether this is influenced by the temporary prosthesis, which is placed 1 month postoperatively, remains unclear. It is important to make the patient aware about this subclinical hypoaesthesia of the palate and upper posterior vestibule. The inhibiting reflex mechanism, which has an afferent connection over the greater palatine and posterior superior alveolar nerve, is likely to be reduced in its function and that might be the reason for early resorption of a bone graft. Atrophic maxilla reconstruction by bone interposition leads to less resorption than onlay techniques (*Sailer*, 1989). Functional loading will further decrease the resorption rates and this might be

achieved by designing the final prosthetic work to be purely implant borne. The incomplete regeneration of the tactile sense 6 months postoperative is another important reason for designing an implant borne prosthesis.

The influence of age on the function of peripheral nerves is well-known in neurology. The conduction velocity decreases electrophysiologically in the elderly (*Mumenthaler* and *Schliack*, 1987). The peripheral nerve can be affected in cases of polyneuropathy. This concerns mainly the long sensory nerves of the lower extremity. Only in exceptional cases are peripheral nerves of the maxillofacial area involved in polyneuropathy. These are usually the nerves supplying the external eye muscles (*Mumenthaler*, 1982; *Mumenthaler* and *Schliack*, 1987; *Lithner* et al., 1991). In our patients, no influence of age on the regeneration of the function of the infraorbital, greater palatine, and posterior superior alveolar nerve was found. Small differences were found 1 month and 3 months postoperatively in the case of the posterior superior alveolar and greater palatine nerves. These differences were caused by differences in the patient samples. In the older patient group more edentulous patients were included. These patients had a slower recovery of sensation.

The influence of the amount of the anterior maxillary movement is demonstrated in Figure 7. Two pairs of large and small movements are noticed with considerable hypoaesthesia and less hypoaesthesia at 1 month and 3 months postoperatively. After a Le Fort I osteotomy with a major anterior maxillary movement (6–10 mm), a less complete regeneration of the function of the greater palatine nerve was noticed at 6 months postoperatively. The cause of these phenomena remains unclear. Probably the difficulty in positioning the maxilla, the duration of the operation and last but not least the position of the hooks, are of the utmost importance for the degree of postoperative hypoaesthesia. These factors are probably more important than the amount of maxillary movement. No correlation could be found between the amount of anterior maxillary movement and the size of the hypoaesthetic area of the infraorbital nerve distribution (Fig. 7). This is probably due to a two dimensional projection of a three dimensional hypoaesthetic area. It might also be possible that the degree of electrically measured hypoaesthesia is not in accordance with the size of the hypoaesthetic area. In Figure 8 it was demonstated that the Le Fort I osteotomies in 2 parts caused more hypoaesthesia of the greater palatine nerve than the Le Fort I osteotomy in 1 part and regeneration is slower. As far as we know this observation has not been made in the literature. None of our patients complained of an hypoaesthetic palate after a Le Fort I osteotomy in two parts and therefore we do not see any reason to avoid it, if from an orthognathic point of view a Le Fort I osteotomy in two parts is necessary. Miniplates gave rise to more hypoaesthesia of the oral mucosa than wires. The cause for this difference might be that more periosteal reflexion is needed for the fixation of miniplates and so more fine nerve endings have to be traumatised. Figure 9 demonstrates the great capacity for regeneration of nerve tissue. Six months postoperatively the difference between miniplates and wires has become much smaller, although the difference is beyond the 0.5 mAmp standard deviation range. The difference after several years was not estimated in this study and will probably be smaller than at 6 months postoperatively.

However, in orthognathic surgery wires are used for fixation of the maxilla after Le Fort I osteotomies especially in cases without relapse tendencies, because it allows for making of minor corrections immediately postoperatively (*Sailer*, 1990). The favourable results of wire osteosynthesis during the first 6 postoperative months are a second reason to continue this strategy. As far as we know the difference in hypoaesthesia between wires and miniplates has never been mentioned in the literature.

CONCLUSION

The infraorbital nerve regains its function completely 6 months after Le Fort I osteotomy. The posterior superior alveolar and greater palatine nerves demonstrate an incomplete recovery of sensory function during the first 6 postoperative months. The risk of pulp necrosis after Le Fort I osteotomy is relatively small, although the observation period of 6 months is rather short. No influence of age on the recovery of function could be found. After a Le Fort I osteotomy in 2 parts there seems to be more hypoaesthesia of the greater palatine nerve than after Le Fort I osteotomy in 1 part. The recovery of sensory function is slower in edentulous patients than in dentate ones.

Miniplates resulted in more hypoaesthesia of the posterior superior alveolar nerve than wire osteosynthesis. The regeneration of sensory function is slower after miniplate osteosynthesis, than after wire osteosynthesis. The final outcome of nerve function after a Le Fort I osteotomy can only be estimated after several years.

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Clinical investigation into the incidence of direct damage to the lingual nerve caused by local anaesthesia

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SUMMARY. **The aim of this study was to investigate the amount of damage to the lingual nerve by mandibular block anaesthesia alone. For this purpose the records of 12104 patients in whom mandibular block anaesthesia was administered without any type of surgery were reviewed. The reason for treatment in those patients was, in 72.4% fillings and crown preparations, in 27.13% periodontal procedures and in 0.30% other treatment. The records showed a lingual sensory disturbance in 18 out of 12104 patients (0.15%). In 17 out of these 18 patients the tongue sensation recovered after a period of 6 months. Only in one patient (0.008%) was there a slight sensory diminution of the tongue, even after one year.**

INTRODUCTION

Injuries to the lingual nerve have proved to be caused most often by the surgical removal of third molars. A large number of papers have been written on damage to the lingual nerve following surgery. The type of incision for opening the mucosa can lead to nerve lesions, as well as the stripping and retraction of the lingual mucoperiosteum, but above all utilization of rotating instruments for the splitting of bone cause lingual nerve lesions (*Machtens* and *Krogmann*, 1985; *Gerlach* et al., 1989; *Cornelius* et al., 1989; *Hoffmeister*, 1989, 1991; *Schultze-Mosgau* and *Reich*, 1993). It is considered to be particularly hazardous to the lingual nerve to elevate the third molars lingually (*Mason*, 1988; *Blackburn* and *Bramley*, 1989; *Rood*, 1992). In contrast, there are only very few investigations, especially on a large scale, of patients with damage to the lingual nerve caused by block anaesthesia alone. *Hickel* et al. (1988) made a study of the damage to the lingual nerve in 1402 patients after block anaesthesia in the mandible for restorative treatment.

The aim of this present study was to find out, in a large series of patients, whether the lingual nerve could possibly be damaged by the injection of local anaesthesia alone, and how high the incidence of lesions was in this case, compared with the overall incidence.

MATERIALS AND METHODS

In a prospective study, data of patients having block anaesthesia to the inferior alveolar nerve were recorded. It was ensured that no surgical manipulation (e.g. third molar removal) falsified the results. Only the records of patients having restorative procedures were evaluated. Block anaesthesia was given mainly by students and a lesser proportion of the patients was treated by residents, especially in the Department of Restorative Dentistry and Periodontology at Erlangen-Nuremberg University. Only patients with normal lingual sensation prior to the injection were included in the study. Block anaesthesia to the inferior alveolar nerve was given intraorally in all instances. The needle was inserted into the spatium pterygomandibulare and directed to the medial side of the ascending mandibular ramus according to the method described by *Frenkel* (1989); there, the anaesthetic solution was infiltrated after contacting the bone. The planned treatment, e.g. the tooth to be treated, as well as the type and amount of the local anaesthetic were recorded. A crucial aspect to be considered was, whether the insertion of the needle into the mucosa had led to an electric shock sensation in the tongue. The patients were asked to return to the dental department the next day after treatment, if the lingual sensation was not the same as before, after anaesthesia had worn off. Those patients were interviewed and examined by a resident who was directly involved in the study. First of all the sensory reaction of the tongue on the treated side was investigated with a sharp pointed probe and with a cotton swab. Thus, it could be determined to what extent the tongue was still numb. Additional complaints, i.e. trismus, pain, swelling and others, were recorded. If a patient showed lingual sensory disturbance, he was given weekly appointments for a period of one month and was then examined again in exactly the same above-mentioned way. If the sensory deficit continued, the patient was followed up at monthly intervals. Thus, we could get exact data on how many patients did not return to normal sensitivity soon after the injection, their exact complaints and how long the disturbances lasted.