Incidence of Neurosensory Disturbance and Success Rates of Solid-Screw Implants Placed in Conjunction with Inferior Alveolar Nerve Transposition

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Abstract

Background: Implant-supported prosthetic rehabilitation of a severely atrophic posterior mandibular alveolar ridge is a real challenge. Implant placement in such situations is very difficult and implies the risk of inferior alveolar nerve (IAN) damage. Purpose: The purpose of this study is to evaluate the incidence of neurosensory disturbance and the cumulative survival of dental implants placed after the IAN transposition (IANT) procedures followed by dental implants placement. Materials and Methods: Twenty International Team for Implantology implants were placed in eight patients following unilateral IANT. In two patients, nerve transposition was performed bilaterally, and hence, a total of 10 IAN transposition surgeries were performed. Neurosensory dysfunction was objectively evaluated by using light touch test (LT), pain test (PT), and 2-point discrimination test (2-DT). In addition, patients were asked to answer a short questionnaire to investigate the individual feeling of discomfort and advantages related to this surgical technique. The mean follow-up periods were 47.1 months (range 12–78 months). Results: Neurosensory disturbance (i.e., disturbance registered by the LT, PT, and 2-DT tests) was experienced in 2 of 10 cases. The cumulative implant survival was 100%. However, at the time of data analysis (12–79 months after surgery), all patients indicated that they would go through the surgery again. Conclusion: IANT can permit the placement of implants with adequate length and good initial stabilization as used in routine sites, with the same favorable prognosis. All patients felt that they had received benefits from their new prostheses in terms of improved comfort, chewing efficiency, and esthetics.

Keywords: Inferior alveolar nerve, neurosensory disturbance, successful implant, surviving implants

INTRODUCTION

Severely atrophic mandible with a highly placed inferior alveolar nerve (IAN) limits the placement of dental implants with optimal implant length. IAN transposition (IANT) is an ideal method in such situations where the mandibular basal bone below the IAN can be wisely utilized for placing implants with sufficient length and initial stability. After an osteotomy, the IAN is pushed aside, and the implants are inserted under direct vision up to the basal bone and the mandibular inferior cortex. Then, IAN placed back in the site passively. Some advantages of this method include the use of longer length implants for better force distribution, minimizing the coronal bone atrophy, and shortening the duration of treatment. The disadvantages of this method include neurosensory problems, temporary mandibular weakness, and lack of anatomic reconstruction of atrophic mandible. Neurosensory disturbance is the most important complication of this procedure.

The aim of this study was to evaluate the IANT procedures followed by dental implants placement and determine the incidence of neurosensory disturbance and cumulative survival and success rates of these implants and patients will receive...
benefits from their new prostheses in terms of improved comfort, chewing efficiency, and esthetics.

**MATERIALS AND METHODS**

Between March 2009 and June 2015, a total of 8 patients, 3 males and 5 females, between 39 and 57 years (average age: 48 years) were treated with distal fixed partial dentures (FPDs) supported by International Team for Implantology (ITI) dental implants placed in conjunction with IANT technique. In 6 of 8 patients, nerve transpositioning was performed unilaterally; in 2 patients, it was performed bilaterally. A total of 20 ITI solid-screw implants were placed through 10 IANT procedures. The present study concerns only implants placed in conjunction with IANT technique, even if the same patient received other implants.

The diagnostic criteria such as a questionnaire, conventional clinical and radiographic examination used in this study were quoted from other articles.[9]

The medical status of patients regarding current and previous diseases and medications was noted; only healthy patients were considered suitable for receiving treatment.

**Preoperative workup**

Preoperative workup included an assessment of the IAN using a panoramic radiograph case for the first patient [Figure 1], a diagnostic wax-up, and surgical template with metal referring point [Figure 2] to determine the height of the bone at the posterior mandible region [Figure 3]. The standardization of ridge to canal distance measured by two-dimensional method using an orthopantomogram and splint retained opaque ball bearing over the ridge. The magnification factor (x) is calculated by the standard procedure of dividing the diameter of the ball in the image (D2) along the actual ball diameter (D1): X = D2/D1. [10-12]

The patients were given oral and written information regarding the risk of postoperative neurosensory dysfunction (NSD), and their written informed consent was obtained.

**Surgical procedure**

Under local anesthesia, a midcrestal incision was utilized to optimally expose the alveolar ridge of the body of mandible, buccal cortex, and the inferior alveolar neurovascular bundle where it exits the mental foramen and enters the soft tissue.

After the removal of the entire outer rectangular cortical window, small curette was used to carefully remove the medullary bone lateral to the neurovascular bundle along the entire length of the bony window. The neurovascular bundle was carefully released from the inferior alveolar canal for the entire length of the osseous window using small curettes and was gently shifted to the side protecting with a smooth instrument. Once the implants were in place, the neurovascular bundle was repositioned to rest on the implants labially [Figure 4]. Following IAN transpositioning, the bone window was covered with demineralized bovine bone mineral (Bio-Oss) of 0.5 mm particle size and resorbable collagen membrane (Bio-Gide, Geistlich, Wolhusen, Switzerland) to prevent mucosal penetration into the surgical site and promote bone regeneration [Figure 5]. When necessary, a horizontal releasing incision was made in the periosteum to enable a tension-free closure. Concerning the healing modality, the submerged approach was utilized for all implants.

**Postoperative treatment and healing period**

After surgery, all patients received oral antibiotics for either 5 or 8 days. For better clinical management and postoperative recovery for any NSD or sensory loss by injury of the IAN, the patients were advised to use anti-inflammatory nimesulide (nimesulide, medley, 100 mg), 1 tablet every 12 h for 5 days, analgesic dipyrone (sodium dipyrone, medley, 500 mg), 300 drops every 6 h for 2 days, and Vitamin B complex (1.5 mg/day) to be assure for patients during healing periods. [13] Patients also underwent low-power laser applications (laser therapy, DMC, Sao Carlos, Brazil) every 3 days for 4 weeks. The sessions were held with the laser using low-power infrared (840 nm and 120 mW) continuously and in timely manner (1 point/cm2) for 30 s, both intraorally and extraorally, following the IAN path on the surgical side. [14] Oral hygiene instructions (mouth rinses with 0.2% chlorhexidine for 2 weeks) were given to all patients.

Sutures were removed 8–15 days after surgery. Implants were allowed a healing period of 3–6 months for osseointegration to be achieved and postoperative radiographs were evaluated before prosthetic rehabilitation began [Figures 6 and 7]. Laboratory procedures, as well as fabrication of prosthetic restorations, were conducted [Figure 8]. Before prosthetic placement, periapical and panoramic radiographs were taken to check the clinical and radiographic situation of the implants. Implant-supported FPDs were cemented as final reconstructions. Periapical and panoramic radiographs were taken to check the clinical and radiographic situation for these cases every 3 months for about 4 years and to record any clinical or radiographic findings within 4 years and after treatments [Figure 9]. Among the available ITI implant configurations in this study, standard solid-screw implants with a diameter of 4.1 mm were always selected. All of the placed implants had an SLA surface. Despite the implant surface characteristics, 12-mm long implants were most frequently used (n = 12) followed by 10-mm long (n = 5) and 8-mm long (n = 3) implants.

**Clinical examination**

Follow-up visits were scheduled for 2 weeks and for 1, 2, 3, 6, 12, 18, and 24 months postoperatively during the first 2 years and annually thereafter. At each annual recall, patients were given a clinical to check pain and discomfort, NSD, peri-implant soft-tissue condition, and radiographic examination to check marginal bone loss or any radiographic changes that affect the osseointegration of the implant. One year postsurgery and at the time, the data analysis was made; all patients were asked...
to verbally answer a short questionnaire [Table 1]. Patients who had bilateral nerve transpositioning were asked to answer the questionnaire both 1 year after the first surgery and 1 year after the second surgery; the second surgery was performed 3–4 months after the first one. Their answers were considered separately for the two surgeries, so 19 answers were collected for each question. Three tests were used to evaluate the NSD of the IAN.\cite{9,15,16}

- **Light touch (LT) test:** This test was performed with a soft feather that the patient could identify in control sites for NSD tests [Figure 10]. With the patient’s eyes closed, a
stimulus was randomly applied to the test sites during 1 of 2 intervals, which were 10 s apart. The patient was asked to identify during which time interval the stimulus had been applied. Each site was tested in blocks of 10 trials. A response of 80% or greater was considered normal. Two sensitivity levels were used: 0 = normal sensitivity and 1 = abnormal sensitivity

- Pain test (PT): This test was performed using a sharp explorer. This test was assumed positive when patients could differentiate between the pressure pain elicited by a blunt tip having the same diameter as the explorer and the pain elicited by the sharp explorer. Three sensitivity levels were used: 0 = normal sensitivity, 1 = decreased sensitivity, and 2 = no sensitivity

- Two-point discrimination test (2-DT): A pair of calipers was opened progressively in 2-mm increments until the patient could discriminate the caliper ends as two separate points of contact. The following scores were used: 0 = normal sensitivity (patients could discriminate between the two tips at a distance shorter than 14 mm); 1 = decreased sensitivity (patients could distinguish between tips only when the calipers were open between 14 and 20 mm); and 2 = no sensitivity (patients could not distinguish between the tips even if they were more than 20 mm apart).

Each test site was made up of two areas; the upper lip was used as the control area for each test [Figure 10]. Abnormalities in either test area detected by any single NSD test or by a combination of the 3 tests were counted as neurosensory disturbance for that particular test site.17

The total neurosensory disturbance (LT + PT + 2-DT) is a sum of the neurosensory-disturbed sites. Since a certain
degree of nerve injury may be expected to occur during the IAN surgical approach, all of the neurosensory disturbances that faded away in a short time (within 1 month) were not included.

**Criteria for success and implant classification**

The implants were examined for successful tissue integration using predefined criteria for success defined taking into account the success criteria established by Buser and Albrektsson et al.\[18,19\]

They were as follows:
1. Absence of persistent subjective complaints, such as pain, foreign-body sensation, and/or dysesthesia
2. Absence of recurrent peri-implant infection with suppuration
3. Absence of mobility
4. Absence of a continuous radiolucency around the implants
5. Marginal bone loss <0.2 mm/year after the 1st year of loading.

First, distinction was made between implants that had not achieved osseointegration defined as “early failed implants” and those that had osseointegrated defined as “successfully integrated implants.” Based on the clinical and radiographic examination, each implant was placed in one of the three categories:
- Failure: An implant was regarded as a failed implant if it had to be removed for any reason
- Survival: An implant was classified as a surviving implant if it was still in service but did not fulfill the success criteria
- Success: An implant was classified as a successful implant if it fulfilled the criteria for success.

If a patient could not be followed at consecutive annual examinations, the corresponding implants were classified as dropouts.

**Life-table analysis**

The statistical analysis included a life-table analysis as described by Cutler and Ederer in 1958.\[20\] To obtain at least 1 year of follow-up for all 20 placed implants, the data analysis was made at the end of September 2016.

In cumulative survival rate, this analysis calculated the annual survival rate and the cumulative survival rate for the entire 6-year period. In this study, the survival rate was defined as the percentage of load-bearing implants that did not fail, including implants that exhibited a supportive peri-implant infection at the last annual examination.

**Results**

The results of the neurosensory examination are described in Table 2. The incidence of neurosensory disturbance detected was 20% (2/10) by LT, 10% (1/10) by PT, and 20% (2/10) by 2 DT. The total neurosensory disturbance (LT + PT + 2-DT) was 20% (2/10). After the 10 IAN transpositions, four patients experienced sensory recovery immediately from local anesthesia. Six patients had neurosensory disturbance. In 3 cases, the patient experienced a total return of sensation within 1 month. Two patients did not experience complete

| Patient number | Age | Time after surgery (months) | Side | Test area | Neurosensory examination | Time to sensory recovery (months) | Implant lose |
|----------------|-----|-----------------------------|------|-----------|--------------------------|----------------------------------|-------------|
| 1              | 42  | 78                          | Right| Lower lip | LT: 1<br>Chin: 0<br>LT + PT + 2-DT: 2 | 12                             | 0/2         |
| 2              | 51  | 72                          | Left | Lower lip | LT: 0<br>Chin: 0<br>LT + PT + 2-DT: 0 | 1                             | 0/2         |
| 2              | 51  | 69                          | Right| Lower lip | LT: 0<br>Chin: 0<br>LT + PT + 2-DT: 0 | 1                             | 0/2         |
| 3              | 39  | 67                          | Right| Lower lip | LT: 0<br>Chin: 0<br>LT + PT + 2-DT: 0 | 0                             | 0/2         |
| 4              | 46  | 58                          | Right| Lower lip | LT: 0<br>Chin: 0<br>LT + PT + 2-DT: 0 | 1                             | 0/2         |
| 5              | 55  | 52                          | Left | Lower lip | LT: 0<br>Chin: 0<br>LT + PT + 2-DT: 0 | 0                             | 0/2         |
| 6              | 49  | 50                          | Right| Lower lip | LT: 0<br>Chin: 0<br>LT + PT + 2-DT: 0 | 1                             | 0/2         |
| 6              | 49  | 48                          | Left | Lower lip | LT: 0<br>Chin: 0<br>LT + PT + 2-DT: 0 | 0                             | 0/2         |
| 7              | 50  | 45                          | Left | Lower lip | LT: 0<br>Chin: 0<br>LT + PT + 2-DT: 0 | 1                             | 0/2         |
| 8              | 48  | 41                          | Right| Lower lip | LT: 0<br>Chin: 0<br>LT + PT + 2-DT: 0 | 0                             | 0/2         |

Time after surgery: Number of months from the time of surgery to the data analysis, Time to sensory recovery: Number of months from the time of surgery to the complete sensory recovery, 0: Immediately after local anesthesia, P: Permanent, still present at the time of data analysis.
recovery until 6 months and 1 patient waited 12 months to obtain complete recovery.

All the other implants were considered to be successfully osseointegrated. Therefore, 20 implants were considered suitable for prosthetic rehabilitation.

During the follow-up period, two implants presented with infection and suppuration in the peri-implant sulcus and radiographic evidence of bone resorption at the last annual examination. These implants were treated with mechanical debridement (carbon fiber curettes plus rubber cups and polishing paste; Hawe Neos, Bioggio, Switzerland), antiseptic treatment (local application of a 0.5% chlorhexidine dental gel for 15 days), and oral antibiotics (omadazole [Tiberal; Roche, Basel, Switzerland] 500 mg twice daily or metronidazole [Flagyl, Rhone-Poulenc, Paris, France], 350 mg three times daily for 10 days). Implant infection was successfully controlled for these two implants. During the study period, based on clinical and radiographic examinations, all the 20 implants fulfilled the predefined criteria for success [Table 3] and were classified as successful implants. All the patients were followed at consecutive annual examinations, so there were no dropout implants. The life-table analysis of the 20 placed implants is shown in Table 3. This table shows cumulative survival and success rates at 78 months (about 6.5 years) of 100%.

Patient answers to the questionnaire are summarized in Table 4. Regarding question 1, although numbness was reported by 10 patients immediately after surgery, after a longer period, i.e. at the time of the data analysis, only three patients remembered this discomfort as important. Regarding question 2, the subject responses and the objective tests were not in agreement at the time of data analysis. The neurosensory tests were more sensitive in detecting neurosensory disturbance than the patients’ evaluation. Regarding question 3, in no case was anesthesia or burning paresthesia reported, and the neurosensory disturbance did not increase since the time of the surgery and did not seem to affect the patients’ daily life. Regarding question 4, all patients would like to do the surgery again and recommend this kind of surgery to their friend or relative. Regarding question 5, all patients felt that they had received benefits from their new prostheses in terms of improved comfort, chewing efficiency, and esthetics.

**Discussion**

Repositioning of the IAN has been used widely as an alternative to short implant or bone grafts for osseointegrated implant placement in the posterior atrophic mandible. IANT is a surgical technique first described by Alling and Fitzpatrick in 1977.[23,24] Jensen and Nock in 1987 were the first to describe the placement of dental implants in the posterior mandible in conjunction with IANT.[25]

This method has not been popular because of the high risk of damaging the IAN. Currently, the use of short implants, osteoregeneration methods, and new prosthetic solutions using inter-foraminal implants have further reduced the use of IANT.[26] However, there are cases in which the transposition of the alveolar nerve is essential to obtain the good morphologic and functional rebalancing of the jaw.

The technique is superior in decreasing the need for bone grafting with the immediate insertion of dental implants in the same surgery, thus reducing the overall treatment time, cost, and donor-site morbidity.[27] Since the major risk of IAN lateralization is neurologic deficiencies of the inferior alveolar bundle and its terminal branches, it should be performed under a strict and meticulous protocol. In 1992, Rosenquist reported 10 interventions for IAN transposition with simultaneous implant insertion.[28] Six months after surgery, 20% of the cases showed persistent nerve dysfunction in the operating regions, although with a return to normal in all cases after one year. On the other hand, Morrison et al.,[29] who performed 26 IAN lateralization procedures, recorded a complaint of only initial sensitivity in the area served by the mental nerve in all patients. These disturbances resolved progressively in less than one month. However, in only 4 cases (15%), sensitivity was improved in six months. However, only in four cases (15%), sensitivity was improved in six months. Accordingly and consistently with other studies,[30] this study used the IAN lateralization technique and most of patients experienced sensory recovery immediately after the local anesthesia or within 1–6 months. This discomfort, however, was well tolerated by patients because they were informed regarding the risk of postoperative NSD and knew that a certain degree of nerve injury could be expected to occur during this particular surgical approach. The neurosensory tests detected that 1 patient had to wait 12 months to obtain complete recovery.

**Table 3: Life-table analysis of twenty implants for implant survival and success rates**

| Time interval (months) | Implants at start of the interval | Dropouts during interval | Implants under risk | Failures during interval | Survival rate within the period (%) | Cumulative survival rate (%) |
|------------------------|----------------------------------|--------------------------|---------------------|-------------------------|-------------------------------------|-----------------------------|
| 0-12                   | 20                               | 0                        | 20                  | 0                       | 100                                 | 100                         |
| 12-24                  | 20                               | 0                        | 20                  | 0                       | 100                                 | 100                         |
| 24-36                  | 18                               | 0                        | 18                  | 0                       | 100                                 | 100                         |
| 36-48                  | 17                               | 0                        | 17                  | 0                       | 100                                 | 100                         |
| 48-60                  | 12                               | 0                        | 12                  | 0                       | 100                                 | 100                         |
| 60-72                  | 8                                | 0                        | 8                   | 0                       | 100                                 | 100                         |
| 72-78                  | 3                                | 0                        | 3                   | 0                       | 100                                 | 100                         |
Because the patients’ answer to question 2 (Do you still have any sensitivity problems with your lower lip or chin?) may be used to evaluate patients’ feeling of disturbance, the results of question 2 were compared with the total neurosensory disturbance tests (LT + PT + 2-DT). Overall, the total neurosensory disturbance tests (LT + PT + 2-DT) seemed to be more sensitive in detecting neurosensory disturbance than was the patients’ evaluation.

In this study, only solid-screw ITI implants with a macroscopic shape showing sharp but not wide threads were used. During the surgical procedure, once the implants were in place, the neurovascular bundle was repositioned to rest directly on the implants that were medial to the IAN. This approach was decided with the hypothesis that direct but passive nerve-to-implant contact was unlikely to damage the nerve. The neurosensory disturbance incidence reported in the present study seems to confirm that the surgical technique used and not the implant shape can cause possible nerve injury.

For all patients in this study, upon postoperative examination, none showed any signs of prolonged neurosensory disturbance, as they provided direct access to the IAN and allowed for its easier identification with subsequent meticulous and careful retraction. Upon implant examination, all installed implants in all patients proved to be clinically stable and osseointegrated at the end of the follow-up period and upon permanent prosthetic loading, which was in accordance with the work of Hirsch and Bränemark, who declared the success of implant osseointegration and stability following the use of IAN lateralization technique in their study.

**CONCLUSION**

A lateral nerve transposition technique, when used in posterior severely atrophied mandibles, can permit the placement of implants with adequate length and with good initial stabilization as used in routine sites, with the same favorable prognosis. All patients felt that they had received benefits from their new prostheses in terms of improved comfort, chewing efficiency, and esthetics.

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Nil.

**Conflicts of interest**

There are no conflicts of interest.

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### Table 4: Patient’s answers to the questionnaire

| Question | 1 year after surgery | Time of data analysis |
|----------|----------------------|-----------------------|
|          | Yes | No | Yes | No |
| 1        | 6   | 4  | 3   | 7  |
| 2        | 2   | 8  | 0   | 10 |
| 3        | 0   | 10 | 0   | 10 |
| 4        |     |    |     |    |
| 5        | 10  | 0  | 10  | 0  |
| 6        | 10  | 0  | 10  | 0  |

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