Retrospective evaluation of mandibular incisor replacement with narrow neck implants

Luca Cordaro
Ferruccio Torsello
Vincenzo Mirisola Di Torresanto
Carlo Rossini

Key words: dental implants, mandibular incisors, narrow diameter implants, narrow neck implants

Abstract: The authors have retrospectively evaluated the clinical results of mandibular incisors replacement with narrow neck implants (NNI). Thirty-one patients treated consecutively for single or multiple lower incisor replacement with NNI with a mean follow-up of 23 months (range 18–42 months) were included in the study and were divided into three groups: single tooth, multiple unit restoration and restorations on adjacent implants. Survival and success rates and soft tissue parameters such as modified plaque index (mPI), peri-implant probing depth (PPD), bleeding on probing (BOP) and the papilla index were analyzed. Subjective evaluation was performed by patients and clinicians on visual analogue scales. The implants and prostheses showed a survival rate of 100% and an overall success rate of 94%. The distribution of mPI outcomes showed better results for the single tooth group. BOP was present in four of eight implants (50%) in the adjacent implant group, in one out of 20 implants in the single tooth group (5%) and in one out of 16 implants in the multi unit group (6%). The adjacent implant group showed a statistically significant increase in PPD. The Papilla Index showed a better outcome distribution in single tooth and multi unit groups. Patients’ evaluation of treatment outcome was satisfactory in all groups, even though the best esthetic and functional results were found in single tooth and multi unit groups. The professional evaluation showed good outcomes for the single tooth and multi unit groups and statistically significant poorer results in the adjacent implants group. With the limitations of this study, it may be concluded that the replacement of lower incisors with NNI leads to favorable functional and esthetic results in cases of single-tooth or multiple-unit replacement. Worse results are achieved if two adjacent mandibular incisors are replaced with adjacent implants.

Treatment of partially edentulous patients with implant-supported restorations has been reported extensively [Jemt et al. 1990; Lekholm et al. 1994; Andersson et al. 1995; Buser et al. 1997]. The anterior mandible has been considered for decades as an ideal implant site when treating edentulous patients [Branemark et al. 1977; Adell et al. 1981; Lindquist et al. 1996]. However, the anterior lower jaw may be considered a difficult site when planning the replacement of mandibular incisors with the aid of oral implants in a partially edentulous patient because of some anatomical and technical problems [Buser & von Arx 2000]. These may lead to non-ideal esthetic or functional results.

The anatomical restriction may include: reduced vertical or transverse dimension of the residual ridge, reduced mesio-distal space available for single or multiple implant placement, crowding or malposition-
ing of the neighbor teeth [Belser et al. 2000; Buser et al. 2000]. The technical complications are due to the dimensions of standard implant prosthetic connections that largely exceed the dimensions of the lower incisor teeth at the level of the cement–enamel junction [Ash 1984].

To overcome the problems related to the reduced bony width, many implant systems have developed narrow diameter implants [Polizzi et al. 1999; Davarpanah et al. 2000; Zinsli et al. 2004]. Prosthetic connections with reduced diameter have been introduced in order to solve the esthetic problems related to the replacement of teeth with reduced dimension [Belser et al. 2000; Andersen et al. 2001].

There are few papers in the literature that report on the mid- or long-term results of narrow diameter implants in the treatment of partially edentulous patients or in single tooth restorations [Polizzi et al. 1999; Vigolo & Givani 2000; Andersen et al. 2001; Zinsli et al. 2004; Comfort et al. 2005]. None of the aforementioned papers specifically refer to the replacement of mandibular incisors.

In this paper, we present a retrospective evaluation of a group of consecutively treated patients who had one or more of their mandibular incisors replaced with restorations supported by one or more narrow diameter implants with a narrow implant prosthetic interface (Narrow Neck Implant, Straumann Dental Implant System, Straumann AG, Waldenburg, Switzerland).

The aims of the study were to describe: (1) hard and soft tissue response to such restorations, (2) patients’ evaluation of the final result and (3) professional evaluation of the treatment outcome.

Material and methods

A total of 446 charts of partially edentulous patients treated with an implant-supported restoration by the senior author between the years 2001 and 2003 were reviewed.

All patients with missing mandibular incisors were analyzed. Multiple-unit restorations were not included if cuspid or bicuspids teeth were part of the rehabilitation, and patients were included in the study if they were treated with a prosthesis replacing only one or multiple mandibular incisors supported only by narrow neck

implants [NNI] from the Straumann Dental Implant System [Straumann AG].

Thirty-one patients matched the inclusion criteria and were included in the study. Eighteen were single incisor replacement (Figs 1 and 2); one patient was treated for the replacement of two lateral incisors while the central incisors were kept in place, four were treated with two adjacent implants supporting two incisors (Figs 3 and 4) and eight had two NNI supporting three- or four-unit fixed partial dentures (FPDs) with no cantilever to replace three or four mandibular incisors (Figs 5 and 6).

The patients were divided into three groups: single tooth [ST group], adjacent implants [AI group] and three- or four-unit

FPDs supported by two non-adjacent implants [MU group]. [Table 1]

Abutment and prosthetic design

Thirty-two implants were restored with porcelain fused to metal [PFM] crowns or bridges cemented over milled or intact titanium copings [Straumann AG]. Four implants were restored with screw-retained PFM crowns with porcelain baked directly over prefabricated gold copings [Straumann AG]. Eight implants were restored with three- or four-unit FPD with porcelain fused to a titanium cast framework that was laser soldered to titanium copings [Straumann AG] and directly secured with screws to the implants.
The patients were recalled, and a complete examination could be performed in all patients.

Medical and dental history was updated and great care was taken in recording adverse effects or complications regarding the prosthetic work object of the study.

A clinical examination was performed including hard and soft tissue analysis and implant stability evaluation [Salvi & Lang 2004]. The soft tissue parameters recorded included the following:

- modified plaque index (mPI) for oral implants [Mombelli et al. 1987];
- bleeding on probing (BOP) around the implants;
- peri-implant probing depth (PPD);
- papilla index [Jemt 1997].

The results obtained for soft tissue parameters were evaluated by dividing the sample into three groups: ST, AI and MU.

Periapical X-rays were taken for each implant at the time of follow up and the distance between the most coronal bone–implant contact and the implant abutment interface was measured. As periapical X-rays at the time of prosthesis delivery were available only for 24 of the 31 patients included in the study, the evolution of crestal bone resorption could not be evaluated. Radiographs were not standardized. However, when making radiographs, care was taken to ensure a parallel position of the film and the implant axis using the paralleling technique [Bragger 1994].

Survival rate was calculated considering the outcome as positive if implants were present and in function in the mouth.

An implant was considered a success when, after the removal of the prosthesis, it satisfied the following criteria: it was clinically immobile (no mobility could be visually discerned, by the unaided eye, when tapping the implant between two instruments’ handles); after 1 year since implant loading the vertical bone resorption was less than 0.2 mm/year; no peri-implant radiolucency was evident in the periapical radiographs; and no signs and symptoms of pain, infection, paresthesia or neuropathy were present [Albrektsson et al. 1986].

Patients’ and professional evaluation of treatment outcome

The patients were asked to indicate their satisfaction on seven visual analogue scales (VAS) consisting of a 10 cm straight line labeled with ‘definitely not’ at the zero point and ‘definitely yes’ at the other end. The distance between the zero point and the mark made on the 10 cm line was measured and expressed in percentage (Chang et al. 1999; Pjetursson et al. 2005) (Table 2). The esthetic outcome was also evaluated by three authors, with the exclusion of the senior author, and reported with the aid of a VAS identical to the one used by the patients (Table 2). The values were pooled and a mean evaluation was obtained for each patient.

The three operators did not know the patients before, so as not to introduce a bias in the judgment. The authors also assessed the possibility for the patient to perform normal oral hygiene easily.

The results obtained were divided into three study groups: ST, AI and MU.

### Table 1. Patient and implant distribution in the study group

<table>
<thead>
<tr>
<th>Treatment type</th>
<th>Single mandibular incisor (ST group)</th>
<th>Two adjacent mandibular incisors (AI group)</th>
<th>Three- or four-unit FPD supported by two non-adjacent implants (MU group)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>19</td>
<td>4</td>
<td>8</td>
<td>31</td>
</tr>
<tr>
<td>No. of implants</td>
<td>20</td>
<td>8</td>
<td>16</td>
<td>44</td>
</tr>
</tbody>
</table>

FPD, fixed partial dentures; ST, single tooth; AI, adjacent implants; MU, multi unit restoration.

### Table 2. Visual analogue scales for patients’ and professional evaluation

<table>
<thead>
<tr>
<th>Statement</th>
<th>Patients’ evaluation</th>
<th>Professional evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAS 1</td>
<td>I feel satisfied with my crown/bridge</td>
<td>I am satisfied with the aesthetic outcome of the rehabilitation</td>
</tr>
<tr>
<td>VAS 2</td>
<td>I bite well with my crown/bridge</td>
<td>I believe that the patient can easily accomplish a good oral hygiene around the restoration</td>
</tr>
<tr>
<td>VAS 3</td>
<td>I feel comfortable with my crown/bridge</td>
<td></td>
</tr>
<tr>
<td>VAS 4</td>
<td>I am pleased with the aesthetic result</td>
<td></td>
</tr>
<tr>
<td>VAS 5</td>
<td>I can clean my implants very well</td>
<td></td>
</tr>
<tr>
<td>VAS 6</td>
<td>I have no pain on my implant</td>
<td></td>
</tr>
<tr>
<td>VAS 7</td>
<td>The tissues around implants do not bleed more than those around the teeth</td>
<td></td>
</tr>
</tbody>
</table>

VAS, visual analogue scales.

### Retrospective evaluation

The patients were recalled, and a complete examination could be performed in all patients.

For numeric values such as PPD and the outcomes of the VAS scales, means and standard deviations were calculated for each group. In order to determine the statistical significance of the differences among the study groups, the mean values were compared with the independent-samples t-test (P < 0.05 was considered significant).

For nominal values such as mPI, papilla index and BOP, the distributions of the outcomes in the different groups were determined. Cross-tabulations were drawn and the Pearson’s χ² test was performed. The cross-tabulation showed the frequency of each index in each group. The χ² test measures the discrepancy between the observed cell counts and what would be expected if the distributions and the study groups were unrelated (P < 0.05 was considered significant).

The statistical analysis has been performed with the aid of the SPSS 13.0 software (SPSS Inc., Chicago, IL, USA).

Statistical analysis was not performed on radiographic measurements as baseline data were not available for all, but only in 24 out of 31 patients.

### Results

#### Success and survival rates of implants and FPDs

The mean follow-up was 23 months, varying from 18 to 42 months. All implants were stable when checked by hand. At the
time of follow-up evaluation, the mean crestal bone level was 0.8 mm apical to the implant-coping junction. Forty-two out of 44 implants demonstrated absence of vertical crestal bone defects. The remaining two implants demonstrated crestal bone resorption on either the distal or mesial aspect so that the bone level was placed more than 2.5 mm apical to the implant-coping junction. These implants belonged to the AI group and are to be considered a partial success. [Albrektsson et al. 1986].

No prosthetic complications were recorded, with the exception of eight patients, who reported one or two instances of loosening of the luting cement.

**Soft tissue evaluation**

**mPI for oral implants**

The differences in distribution of the mPI indicated better plaque control around single-tooth and multiple-unit restorations when compared with adjacent implants. However, as these data were significant only at the level of \( P < 0.1 \), it is not possible to draw definitive conclusions.

**BOP around the implants**

There was BOP around six out of the 44 [14\%] implants evaluated in this study. Regarding the different groups, the BOP was positive for one out of 20 implants of the ST group [5\%], for four out of eight implants of the AI group [50\%] and for one implant out of 16 of the MU group [6\%]. The differences among the study groups tested with the \( \chi^2 \) test were significant \( ( P < 0.01) \).

**PPD**

The mean PPD recorded was \( 3 \pm 0.4 \) mm. The mean value for the AI group [3.6 \pm 0.6] was greater than the mean values for the ST group [2.9 \pm 0.2] and the MU group [2.9 \pm 0.3]. The differences between ST and AI groups and between MU and AI groups were statistically significant \( ( P < 0.01) \), while the differences between ST and MU were not significant.

**Papilla index (Table 3)**

The cross-tabulation shows the tendency towards better scores for the single-tooth and multiple-unit restorations. In the AI group, only two out of 12 papillae showed at least half of the papilla height. The differences among the study groups were significant \( ( P < 0.01) \). It should be noticed that two papillae were evaluated for each implant in the ST group, three papillae for rehabilitation in the AI and four papillae for prosthesis in the MU group (adjacent to implants).

**Table 3. Crosstabulation of the distribution of the results for papilla index in the different groups (Jemt 1997)**

<table>
<thead>
<tr>
<th>Papilla index</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single tooth</td>
<td>2</td>
<td>8</td>
<td>10</td>
<td>19</td>
<td>1</td>
<td>40</td>
</tr>
<tr>
<td>Adjoint implants</td>
<td>4</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>Multi-unit restoration</td>
<td>5</td>
<td>7</td>
<td>17</td>
<td>3</td>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>22</td>
<td>29</td>
<td>23</td>
<td>1</td>
<td>84</td>
</tr>
</tbody>
</table>

0, papilla present; 1, less than half of the height of the proximal area occupied by the soft tissue; 2, at least half of the height of the proximal area occupied by the soft tissue; 3, the entire proximal space is filled with soft tissue in good harmony with adjacent papillae; 4, hyperplastic papilla. The results of the Pearson’s \( \chi^2 \) test showed that the differences in distribution are statistically significant \( ( P < 0.01) \).

**Table 4. Patients’ judgment of treatment outcomes reported on the VAS ranging from 0 to 100 (Means and SD values calculated for each group)**

<table>
<thead>
<tr>
<th>I feel satisfied with my crown/bridge</th>
<th>I bite well with my crown/bridge</th>
<th>I feel comfortable with my crown/bridge</th>
<th>I am pleased with the esthetic result</th>
<th>I can clean my implants very well</th>
<th>I have no pain on my implant</th>
<th>The tissues around implants do not bleed more than those around the teeth</th>
</tr>
</thead>
<tbody>
<tr>
<td>SI</td>
<td>90 \pm 6</td>
<td>87 \pm 12</td>
<td>88 \pm 10</td>
<td>96 \pm 4</td>
<td>92 \pm 8</td>
<td>96 \pm 8</td>
</tr>
<tr>
<td>AI</td>
<td>75 \pm 10</td>
<td>81 \pm 17</td>
<td>77 \pm 15</td>
<td>82 \pm 10</td>
<td>68 \pm 11</td>
<td>83 \pm 19</td>
</tr>
<tr>
<td>MU</td>
<td>83 \pm 7</td>
<td>78 \pm 15</td>
<td>80 \pm 15</td>
<td>92 \pm 6</td>
<td>89 \pm 8</td>
<td>96 \pm 9</td>
</tr>
</tbody>
</table>

VAS, visual analogue scales; SD, standard deviation; SI, single tooth; AI, adjacent implants; MU, multi unit restoration.

**Patients’ and professional evaluation with VAS**

The high scores on the VAS no. 1, 2, 3 and 6 demonstrated that patients were satisfied regardless of the type of restoration provided (ST, AI or MU) as the discrepancies between groups are not statistically significant. However, for what concerns patient’s perception of the esthetic outcome, the possibility to clean the restorations and the tendency to bleed for the soft tissue (VAS no. 4, 5 and 7), there were statistically significant \( ( P < 0.01) \) differences between ST and AI groups and between MU and AI groups, while the discrepancies between ST and MU were not significant (Table 4).

The clinicians found great differences among the groups in the esthetic outcome and in the possibility to perform good oral hygiene. In particular, the group with two adjacent implants showed statistically significantly \( ( P < 0.01) \) poorer results when compared with the other groups (Table 5).

**Discussion**

When analyzing the results of this retrospective evaluation, some considerations need to be made. The relatively small study sample (31 patients and 44 implants) and its division into three subgroups makes statistical analysis critical, especially as...
The replacement of mandibular incisors with narrow neck implants allows for a stable and functional replacement of mandibular incisors. No implants were lost and all the crowns or FPDs are in function. The success rate was high for ST and MU groups (100%) and reduced for the AI group (75%). Single mandibular incisor replacement resulted in optimal functional and esthetic results.

Three- or four-unit FPDs supported by two NNI placed in the region of lower incisors achieved optimal functional and esthetic results. With the limitations of the present study, which included a reduced number of patients, it can be suggested that replacing two adjacent mandibular incisors with two NNI may be associated with poor aesthetic results and inefficient plaque control.

### Table 5. Professional evaluation of treatment outcomes reported on VAS the VAS ranging from 0 to 100 (Means and SD values calculated for each group)

<table>
<thead>
<tr>
<th></th>
<th>I am satisfied with the esthetic outcome of the rehabilitation</th>
<th>I believe that the patient can easily accomplish good oral hygiene around the restoration</th>
</tr>
</thead>
<tbody>
<tr>
<td>SI</td>
<td>85 ± 11</td>
<td>87 ± 11</td>
</tr>
<tr>
<td>AI</td>
<td>44 ± 8</td>
<td>33 ± 16</td>
</tr>
<tr>
<td>MU</td>
<td>82 ± 8</td>
<td>74 ± 14</td>
</tr>
</tbody>
</table>

VAS, visual analogue scales; SD, standard deviation; SI, single tooth; AI, adjacent implants; MU, multi-unit restoration.

Conclusion

The use of narrow diameter implants with a narrow prosthetic platform (NNI) allows stable and functional replacement of mandibular incisors.

one group contains only four patients and eight implants. However, in the smaller group, even if it is not possible to address definitive conclusions, some indications can be found.

It must be noticed that the NNI has been designed for single tooth restorations and that its use in multiple-unit restorations has not been extensively reported so far [Buser & von Arx 2000; Cehreli & Akca 2004].

The authors have used such an approach relying on the reduced functional load of the lower front teeth. The replacement of mandibular incisors with NNI appears to be safe and effective as demonstrated by high survival and success rates. From the esthetic point of view, the results reported are different in relation to the type of restoration provided to the patient. The patients’ evaluation of the esthetic outcome has been largely positive in MU and SI groups. A worse, but acceptable, result for the restorations supported by two adjacent implants was recorded. This is probably due to the reduced esthetic impact of the gingival contours of the mandibular front teeth that are rarely visible.

On the other hand, it should be noted that the aesthetic evaluation performed by the authors was very different between the three groups. The mean VAS reported for crowns on adjacent implants was 44, while the mean score for the single-tooth replacement was 85 [difference significant for P<0.01]. This is also confirmed by the distribution of the papilla index. If evaluated from the clinician’s point of view, it is not possible to consider as satisfactory the esthetic outcome of two adjacent NNI implants replacing mandibular incisors.

The esthetic results are mainly correlated with problems related to the available prosthetic space, to the dimensions of the teeth to be replaced, and to the dimensions of the hardware to be used for such restorations.

The mean mesio-distal width of the crowns of central and lateral lower incisors at the level of the contact points is between 5 and 5.5 mm, which reduces to between 3.5 and 4 mm at the level of the CEJ [Ash 1984].

Some authors have suggested the need to maintain at least 3 mm of inter-implant space at the level of the implant–abutment or implant–prosthesis interface to achieve the crestal bone support necessary for optimal soft tissue esthetics [Tarnow et al. 2000]. Moreover, it has been suggested to maintain a distance of at least 1 mm between implants and teeth [Buser & von Arx 2000; Choquet et al. 2001]. In an ideal situation, if two adjacent lower incisors are missing, 11 mm should be available in the dental arch (5.5 mm of mean crown width).

If two implants are to be placed in this situation, the management of the mesio-distal dimension at the crestal level becomes critical because, even when using NNI (prosthetic connection 3.5 mm), 1 mm of implant to tooth distance per side, and 3 mm of inter-implant distance should be guaranteed. This calls for a required mesio-distal space of 12 mm. So replacement of mandibular incisors with two adjacent implants may interfere with the achievement of an ideal inter-implant distance.

The results obtained in our series with replaced adjacent mandibular incisors confirmed these considerations, as esthetic outcome was judged as unacceptable by the authors even if most of the patients were satisfied with the appearance. The clinicians judged that in the AI group, it is very difficult for the patient to maintain a good oral hygiene, as the reduced inter-implant space reduces the possibility of performing correct hygiene [Fig. 4]. Moreover, the mPI was higher in this group and the only two implants that showed peri-implant crestal bone resorption were part of this group. It seems that if two adjacent lower incisors are missing, other treatment options should be considered.

要旨
本研究では、ナロー・ネック・インプラントで下顎切歯の補綴治療を行った症例の臨床的結果を後向きに評価した。対象は、ナロー・ネック・インプラントによって単独あるいは複数の下顎切歯の補綴治療を受け、平均経過観察期間が12ヶ月以上（最少4ヶ月）で20名の41症例である。これらの症例を、単独歯修復、複数ユニットの補綴物および隣接する2本のインプラントグリップを支持する補綴物の3群に分類した。存続率と成功率、およびプラーグ指数変化、インプラント周囲のプロービング深さ、プロービング時の出血、骨齢変動インデックスなどの軟組織パラメータを分析した。患者と治療者は視覚アナログスケール（VAS）を用いて主観的な評価を行った。

インプラントと補綴物の存続率は100％、全体的な成功率は94％であった。mPIインデックスの分布は、単独歯群がより良い結果を示した。プロービング時の出血は、隣接インプラント群ではインプラントの長さに応じて、隣接インプラント群ではインプラントの長さに応じて、1月後では50％、2月後では20％のうち1本、3月後では16本のうち1本に認められた。隣接インプラント群はインプラント周囲のプロービング深さが統計学的に有意に高かった。

References


