Immediate Replacement of Single Teeth With Immediately Loaded Implants: Retrospective Analysis of a Clinical Case Series

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Introduction: *The purpose of this retrospective analysis of clinical data was to evaluate the predictability of replacing failing single teeth with immediately placed implants loaded via a transitional (provisional) restoration.*

Materials and Methods: *Implants were placed immediately at the time of extraction of failing single teeth that met predetermined inclusion criteria. A detailed protocol was followed to enable immediate loading of the implant with the use of prefabricated abutments in combination with transitional restorations.*

Results: *A total of 375 immediate implants had been placed in 274 patients and loaded immediately. With the certainty of 95%, an estimated overall mean survival rate better than 97.6% was observed after a mean observation period of 36 months. The maximum observation period was 142 months. Four implants had been lost in function.*

Conclusion: *Immediate loading of immediately placed implants is a possible treatment option that might be predictably and successfully achieved. Implants of adequate primary stability coupled with a range of prefabricated abutments permit function to be achieved using transitional restorations. The preliminary results of this clinical case series are very promising. (Implant Dent 2017;26:30–36)*

Key Words: immediate dental implant loading, dental implant-abutment design, osseointegration, dental, dental implant abutment connection, dental implantation

The scope and success of conventional staged treatment is well established. Immediate loading of implants was established by Ledermann and depended upon rigid splinting of multiple implants.[1–3] Recent publications have demonstrated comparable survival rates between immediate and delayed loading of implants.[4]

Immediate replacement of teeth using a protocol of loading on integration with predictable outcomes was described in the 1970s and raised an interest by claiming to reduce bone remodelling.[5–7] Recent observations have been made about the high success rates coupled with comparable bone levels irrespective of immediate or delayed loading of immediately placed implants.[8] This study was based on unsplinted implants replacing single teeth.

Immediate placement and loading requires adequate primary stability of the implant. This may require the implant to be placed at an inclination to make best use of the available bone. Therefore, an appropriately shaped abutment is required to bring the implant into function and compensate for the angle at which the implant might be placed. The long-term outcome of prefabricated angled abutments in combination with a delayed loading protocol has previously been described.[9–12]

AIM

The aim of this analysis is to evaluate the clinical outcome that can be achieved using implants immediately placed into freshly extracted tooth sockets and loaded immediately using transitional restorations in combination with prefabricated angled abutments.

METHODS AND MATERIALS

A retrospective analysis of routine clinical data of patients treated using immediately placed and provisionally loaded implants, gathered in a single private practice, was performed.

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Table 1. Patient-Monitoring Protocol Beginning 1 Week After Implant Insertion

Time after Immediate Placement and Loading	Monitoring Protocol
1 wk	Photographs Clinical assessment
3 mo	Radiographs Photographs Clinical assessment Restorative procedure
3 mo postrestorative review	Radiographs Photographs Clinical assessment
24 mo postrestorative	Radiographs Photographs Clinical assessment
Every 2 y	Radiographs Photographs Clinical assessment

Clinical and radiographic assessment continues 3 months after implant placement according to a specific monitoring protocol, as described in the table, to allow changes in bone and soft tissue levels to be monitored.

Consent

All patients were informed of all treatment alternatives, the risks, and benefits of the proposed treatment including the clinical requirements outlined below. Consent was gained for the use of photographs and gathering of clinical data for anonymized analysis and publication. Only patients who consented underwent treatment.

Institutional Review Board (IRB) Exemption

No systematic data collection beyond that which is part of routine clinical practice was performed and the retrospective analysis of the data therefore is exempt from IRB oversight as per letter of exemption from Chesapeake IRB (6940 Columbia Gateway Drive, Columbia, MD 21046).

Inclusion Criteria

Patients were considered suitable for treatment with immediate replacement of failing teeth with implants in the absence of systemic contraindications and if they met the following inclusion criteria in assessing each individual tooth:

- No acute pathology present (absence of symptoms).
- Socket was preoperatively assessed to be intact by periodontal probing.
- Adequate bone available for primary stability to be achieved.

1. For single rooted teeth, this was identified beyond or adjacent to the tooth socket.
2. For multiple rooted teeth, the root morphology needed to be suitable to permit implant placement either into one of the residual sockets, the interradicular bone or by obliterating the entire socket or socket complex.

- Soft tissues had to be adequate, especially in the aesthetic region.

Exclusion Criteria

- Labial dehiscence or fistula at the time of assessment of residual socket.
- Loss of labial plate during extraction.
- Inability to achieve the required insertion torque of 25 N·cm.
- Inability to position the implant into a restorable position (eg, mesio-distally or bucco-lingually).

Table 2. Reason for Loss of Follow-up

Reason	No. Patients	% Patients	No. Implants	% Implants
Patient moved away	1	0.4	2	0.5
Patient deceased	4	1.5	6	1.6
Monitored by referring dentist	40	14.6	45	12.0
Not responded to recall	28	10.2	30	8.0
Total	73	26.6	83	22.1

Frequency of patients, which were lost to follow, is listed based on the reason. The largest number of patients, which were lost to follow-up, is monitored by the referring dentist. Twenty-eight patients (10%) did not comply with our monitoring protocol.

Assessment of Failing Teeth

Radiographic and clinical assessment was to be carried out to ensure that the above criteria are met.

Clinical examination was carried out following standardized protocol to eliminate pathology elsewhere in the mouth. This included a detailed periodontal examination of the failing tooth. The absence of increased probing depths was considered as a preliminary observation to be indicative of an intact socket to be verified following extraction as previously described.[13,14]

Dental panoramic tomograms (DPT's) and periapical radiographs were taken as preliminary investigations. 3-dimensional imaging using cone-beam CT scans (CBCTs) was used whenever applicable to provide further information about the root morphology, surrounding bone, and adjacent anatomical structures. CBCTs were also used to provide information about the density of bone in Hounsfield units (HU) beyond the roots as a rough guide. Reliable data would depend upon exposures in the region of 120 kVp.[15] Interactive planning was performed using Simplant software (Materialise Dental NV, Leuven, Belgium).

Clinical Protocol

The clinical process was as follows.

Extraction. Teeth were extracted using a flapless approach and care was taken to minimize damage to tissues. The integrity of socket was established using a periodontal probe.

Implant insertion. Implant insertion was carried out to achieve the desired primary stability. An implant system with a tapered body and deep threads was used (Ankylos Implant System; Dentsply Implants, Mannheim, Germany). The recommended drilling protocol for the Ankylos implant system

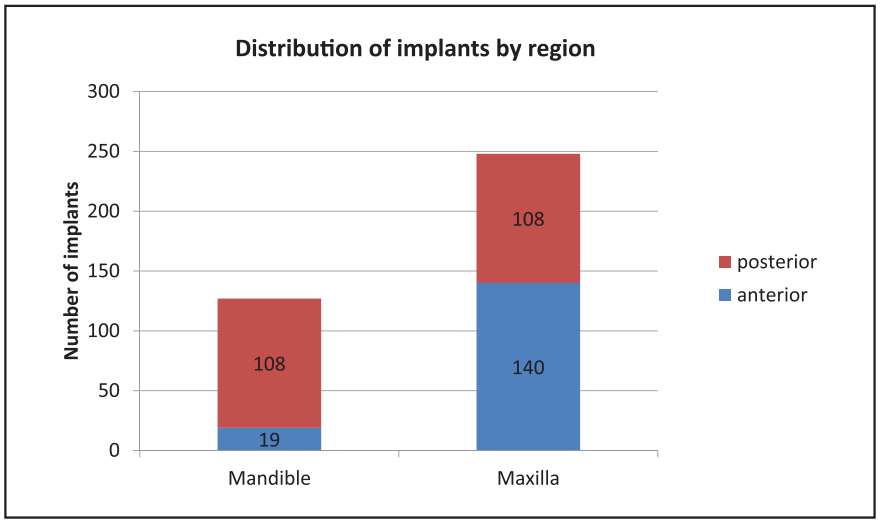


Fig. 1. Distribution of immediately placed and loaded implants is depicted by anatomical region. The largest number of implants (140 implants) was placed in the anterior maxilla, followed by the posterior maxilla and mandible in equal numbers (108 implants). The smallest number of implants was placed in the anterior mandible (19 implants).

was followed.[16–18] A minimum insertion torque of 25 N·cm was required before immediate loading as measured using a torque wrench. Prefabricated abutments with a range of angles, dimensions, and different sulcus heights were obtained in advance. Choice of abutments with a nonindexed conical connection enabled the abutments to be aligned free of rotational constraints to achieve alignment within the prosthetic envelope. Implants were inserted to 1.5 to 2 mm below and palatal to the labial socket margin. This permitted the attachment of the abutment of the correct sulcus height to achieve the intended emergence profile as described elsewhere.[13,14]

Abutment attachment and transitional restoration. Abutment attachment was carried out by connecting the correct abutment in the ideal position and tightened to 15 N·cm to engage the conical connection. Interference with the bony socket was prevented. Ceramic abutments were used with patients who had high lip lines, displaying the gingival margins. Titanium abutments were used in all other cases and in the posterior quadrants. Prefabricated acrylic sleeves were seated on the titanium abutments to facilitate the construction of the transitional restoration. The prefabricated hollow acrylic transitional restoration was connected to the sleeve using self-polymerizing resin or relined directly onto the abutment. A very small amount of temporary cement (Temp bond; Kerr, Orange, CA) was used to lute the closely fitting transitional crown. The transitional restorations were designed on a study cast to fit passively and accurately within the socket outline to contain the clot within the socket and to support the soft tissues. Transitional restorations were adjusted, so that there was no contact in maximum intercuspal position or excursions. Documentation of soft tissue contours was carried out photographically and a periapical radiograph provided documentation of bone-levels as well as clearance from adjacent anatomical structures.

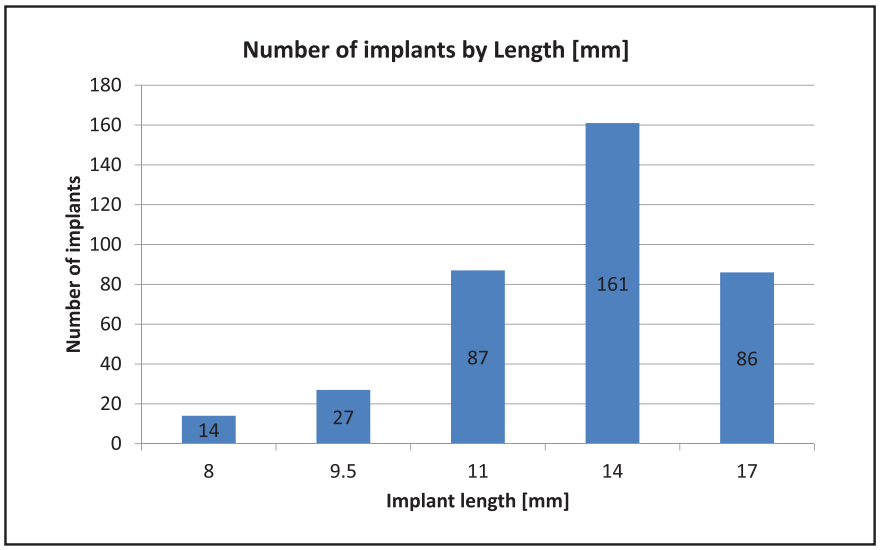


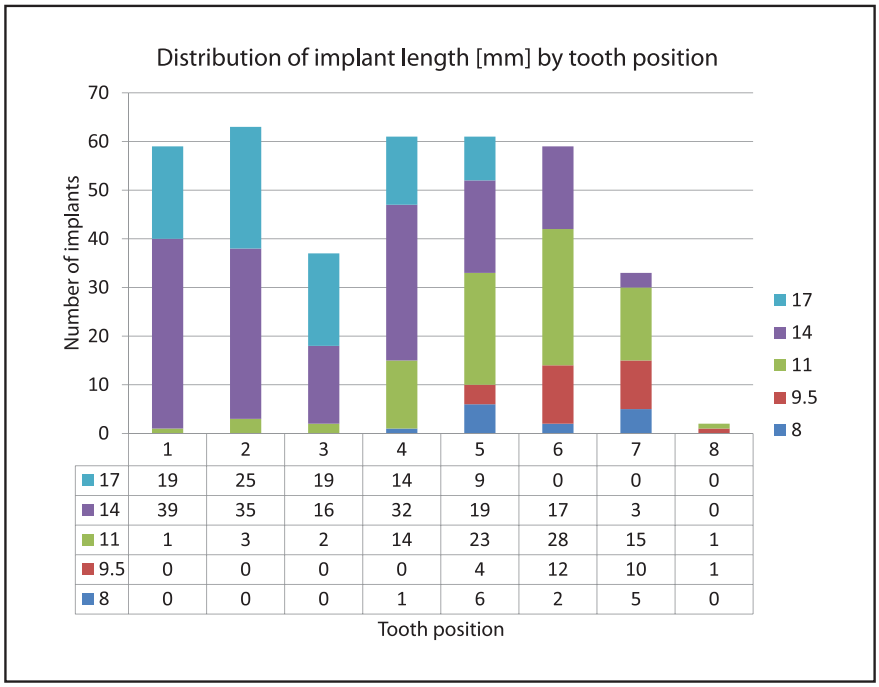
Fig. 2. Frequency of implant length. Fourteen millimeters long implants were the most commonly used implants (161 implants) followed by 11- and 17-mm-long implants (87 and 86 implants, respectively). A smaller number of 9.5 mm (27 implants) and 8 mm (14) implants were used as well.

Restorative treatment. Restorative treatment was commenced 3 months after insertion on completion of integration. Direct conventional impressions of the abutment were taken for the fabrication of cement retained all ceramic or metal-ceramic crowns.

Patient recall and data collection. Patients were seen 1 to 2 weeks after implant insertion, as well as at 3-month postinsertion. The following criteria were assessed:

- Absence of pain and inflammation.
- Rigidity of implant by percussion testing.
- Security of transitional restoration.
- Adequate oral hygiene.

Periapical radiographs were taken directly postoperatively, after 3 months, and postrestoration. A long cone technique and "Rinn" paralleling system was used (RinnXCP film holders; Rinn, Elgin, IL). On completion of the



	1	2	3	4	5	6	7	8
17	19	25	19	14	9	0	0	0
14	39	35	16	32	19	17	3	0
11	1	3	2	14	23	28	15	1
9.5	0	0	0	0	4	12	10	1
8	0	0	0	1	6	2	5	0

Fig. 3. Distribution of implant length by tooth position. The longest implants have mainly been used in the anterior region, extending to the 2nd premolar (14 and 17 mm implants). The majority of the short implants (8, 9.5, and 11 mm) were used in the posterior quadrants.

restoration, the patients were reviewed and baseline records made. Further reviews took place and are summarized in Table 1. Radiographs and photographs were also taken at each recall visit and any adverse events were recorded.

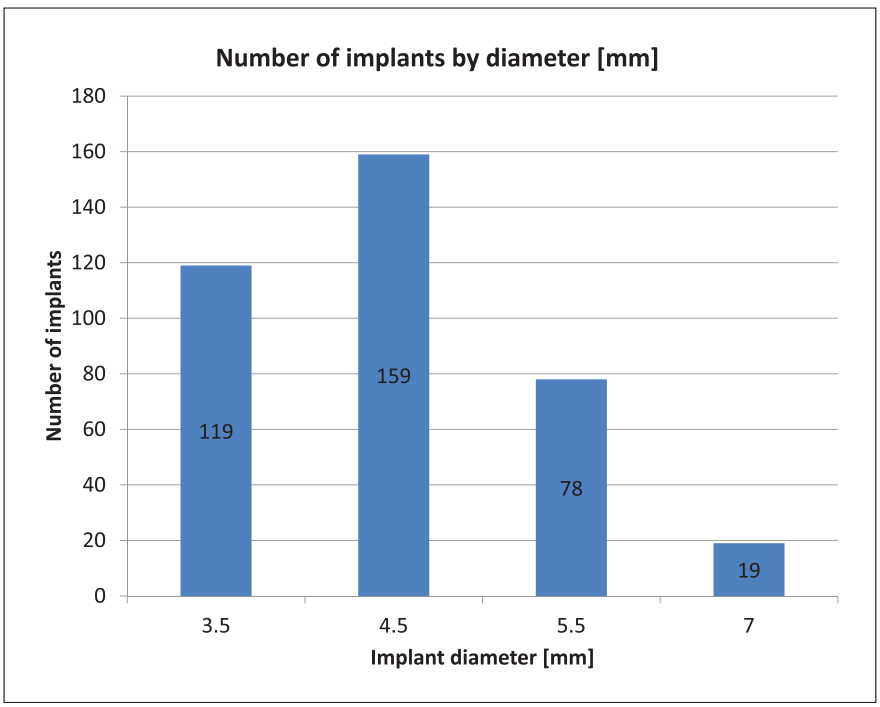


Fig. 4. Frequency of implant diameter used. The largest number of implants had a diameter of 4.5 mm (159 implants) followed by 3.5-mm-diameter implants (119 implants). Seventy-eight 5.5 mm implants were used and the 7-mm-diameter implants were used least frequently.

Calculations and statistics. The clinical data were transferred into a database format (Microsoft Access; Microsoft, Redmond, WA). Statistical analyses were made with a statistical program (JMP; SAS Institute Inc., Cary, NC).

Distributions were either depicted by means of frequency tables, histograms or with outlier box plots. The outlier box plot visualizes the sample distribution and helps to identify points with extreme values, or outliers. The ends of the box are the 25th and 75th quantiles, also called the quartiles. The difference between the quartiles is the interquartile range. The line inside the box represents the median sample value. The ends of the whiskers are the outermost data points from their respective quartiles that fall within the distance computed as 1.5 times (interquartile range). The mean value of the distribution is represented by the diamond. The width of the diamond represents the 95% confidence interval for the group.

A Kaplan–Meier survival analysis was performed.

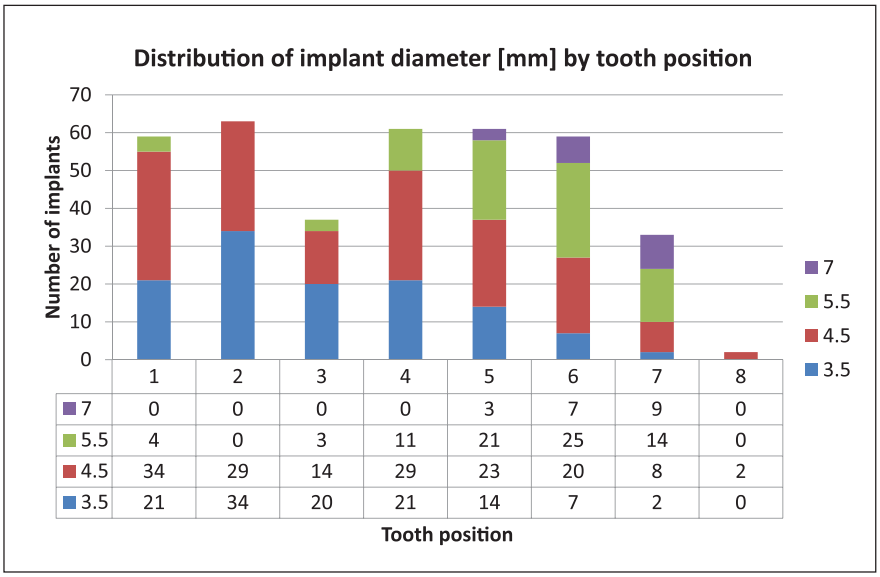
RESULTS

Patients Lost to Follow-up

There were 274 patients with a total of 375 implants included in the retrospective analysis. Seventy-three patients (26.6%) with a total of 83 implants (22.1%) were lost to follow-up at the practice. Forty patients (14.6%) patients with 45 implants did not attend the recall program and have been monitored by their referring dentist with instructions to return or to be referred back in case of postoperative issues. Twenty-eight patients (10.2%) have not complied with requests to attend for monitoring. A number of these patients were referred from greater distances. One patient (0.4%) moved away from the area and is unable to attend regularly. A further 4 patients (1.5%) are deceased. The reasons for loss of follow-up are summarized in Table 2.

Distribution of Implants Used

Of the 375 implants that were placed, 216 (57.6%) were placed in the posterior quadrants, whereas 159 (42.4%) were placed in the anterior



	1	2	3	4	5	6	7	8
7	0	0	0	0	3	7	9	0
5.5	4	0	3	11	21	25	14	0
4.5	34	29	14	29	23	20	8	2
3.5	21	34	20	21	14	7	2	0

Fig. 5. Frequency of implant diameters by tooth position. Narrower diameter implants of 3.5 and 4.5 mm diameter were mostly used in the anterior region. Wider diameter implants of 5.5 and 7 mm were most commonly used in the posterior quadrants, though exceptions to this can also be seen.

region. One hundred eight implants were placed in the posterior maxilla and mandible. One hundred forty implants were placed in the anterior maxilla and 19 in the anterior mandible. Figure 1 depicts the distribution described above.

Frequency of Implant Length and Diameter Used

The length of the implants used is depicted in Figure 2. Two hundred forty-seven (65.9%) of the implants used were 14 mm or longer. Forty-seven (10.9%) implants were 9.5 mm or shorter. The remaining 87 (23.2%) implants were 11 mm long. The detailed distribution of implant lengths by tooth position is depicted in Figure 3.

A variety of implant diameters were used ranging from 3.5 to 7 mm as depicted in Figure 4. One hundred nineteen (31.7%) were 3.5 mm in diameter and 159 (42.4%) were 4.5 mm in diameter. This constituted 74.1% of the implants used. The remainder of the implants that were used had a diameter of 5.5 mm—78 implants (20.8%)—and 7 mm—19 implants (5.1%).

The details of the distribution of different implant diameters by tooth position are depicted in Figure 5.

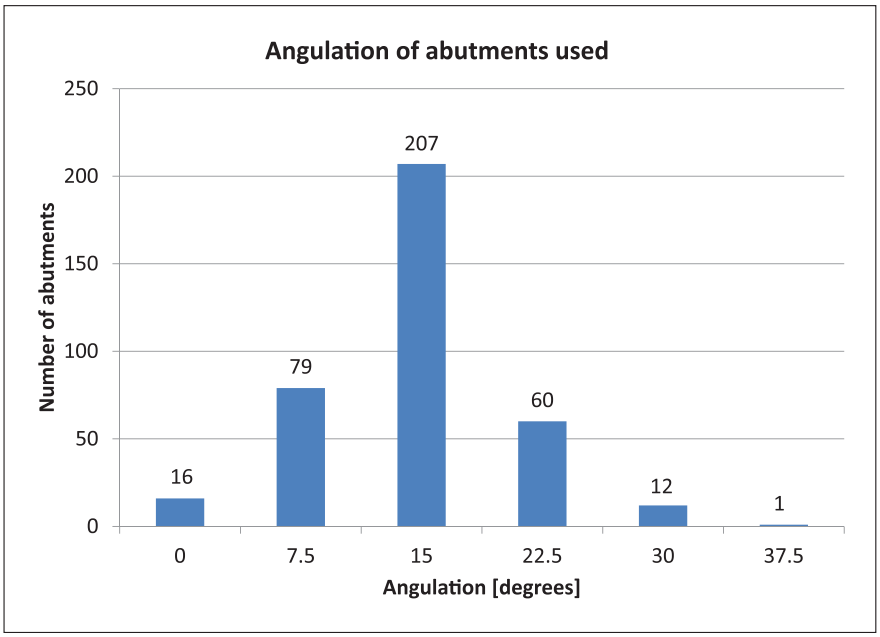


Fig. 6. Distribution of abutment angulations required to immediately restore implants. Angulations ranging from 0 to 37.5 degrees were used. The largest number of abutments ranged from 7.5 to 22.5 degrees (346 out of 375 implants).

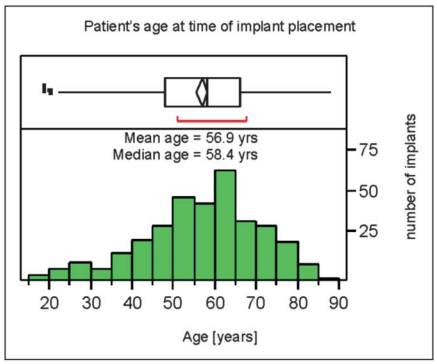


Fig. 7. Histogram and box plot—Age of patient at time of implant placement. The mean age of patients was 56.9 years and ranged from 18 to 88 years.

Abutment Angulation

The full range of abutment angles used ranged from 0 degrees to 37.5 degrees in 7.5 degrees increments.

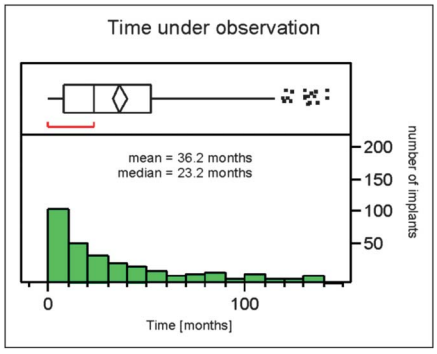


Fig. 8. Histogram and box plot of time under observation. The maximum time under observation of all implants was 142.6 months. Fifty percentage of the implants (median value of time since placement) were placed within 23.2 months.

Angles of 15 degrees and above were used in 74.7% of the cases.

Figure 6 shows the distribution of different abutment angulations.

Age of Patients

Patients with a range of ages varying from 18 to 88 years at the time of implant placement have been treated. The mean age of all patients treated was 56.9 years. Figure 7 shows the age distribution at the time of implant placement as a histogram and box plot.

Survival Analysis

The maximum time under observation of all implants placed is 142.6 months. The mean period of observation is 36.2 months. Fifty percentage of the implants (median value of time since placement) were placed within 23.2 months before May 2013 (Fig. 8).

Of the 375 implants placed, 4 failed to integrate and were lost within the first 7 months after placement and loading. The remainder of the implants have so far survived as depicted by the Kaplan–Maier survival curve (Fig. 9). With a certainty of 95%, an estimated survival rate better than 97.6% was calculated after a mean observation period of 36.2 months as well as after an observation period of 50.2 months (ie, based on 100 implants under observation, 95% confidence interval (CI) = 98.77 ± 1.2%).

Figure 10 depicts Kaplan–Maier survival curves of 2 groups of implants, those restored with abutments of 15 degrees and less and those restored with abutments of more than 15 degrees. There is no difference detectable between the 2 groups because the 95% confidence intervals overlap.

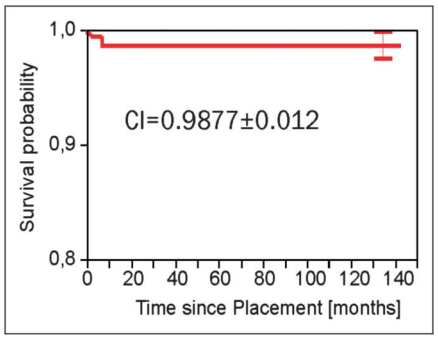


Fig. 9. Kaplan–Maier survival curve of all implants since placement. With a certainty of 95%, an estimated survival rate better than 97.6% was calculated after a mean observation period of 36.2 months.

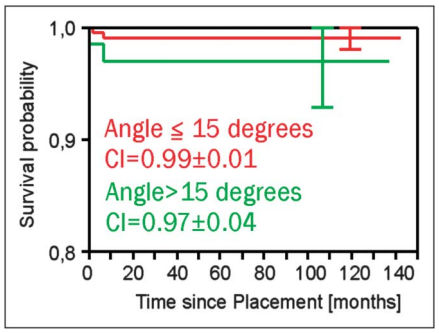


Fig. 10. Kaplan–Maier survival curve comparing implants with abutments of more than 15 degrees angulation versus abutments of 15 degrees and less. The 95% confidence intervals are overlapping, indicating that there is no statistical difference between the 2 groups.

DISCUSSION

Implants longer than the actual length of the root of the extracted teeth were often used. Longer implants enabled engagement of bone available beyond the extraction socket. As depicted in Figure 3, the longest implants have been used in the anterior region. This is a result of the greater amount of bone that is available in this region. Figure 1 shows the planning for an implant of 14 mm length in the anterior maxillary region, which is typical of the anatomical structures here. The shorter implants in the posterior quadrants reflect the anatomical limitations created by the maxillary sinuses and the inferior alveolar canal.

Implants of various diameters have been used. Figure 5 is reflective of the anatomy of the various regions. The wider diameter implants have been predominantly used in the premolar and molar regions. The use of wider implants in the posterior quadrants results from the need to obtain primary stability from the lateral walls due to anatomical limitations. Interestingly, narrow implants in the molar regions were often used for interseptal placement or the utilization of a single socket of multirooted teeth, when correctly positioned. This offered the opportunity for treatment to be carried out in one stage, minimizing the trauma for the patients. This was as an alternative to carrying out the treatment in stages. The use of implants of 3.5 mm diameter in the posterior region is well documented.[19]

Implants were placed to utilize the maximum amount of bone available to achieve optimum primary stability. The choice of a screw-type implant with a deep progressive thread was consistent with *in vitro* research that addresses the impact of thread depth, screw diameter, and self-tapping on screw stability.[20] Furthermore, the surgical protocol of not tapping or undersizing the osteotomy was also used in poor quality bone to achieve primary stability of more than 25 N·cm as measured using a torque wrench. These principles are well established.[21,22]

Prefabricated angled abutments were selected to fit within the prosthetic envelope and seated. This enabled the transitional restorations to be fitted on that day. Other authors have described the construction of an abutment and transitional restoration to be delivered up to 1 week after placement based on an impression taken at the time of implant insertion.[23–25]

This clinical case series utilized cement-retained restorations. Excess cement, particularly permanent hard cement injudiciously forced subgingivally, can result in serious compromise of hard and soft tissues.[26–30] The potential risk of excess cement was minimized by estimating the correct amount of temporary cement. The use of the definitive abutment aimed to avoid subsequent disconnection and reconnection of implant components with possible soft tissue compromise.[31,32]

The survival analysis demonstrated a high survival rate with no significant difference relating to the use of larger abutment angulations. The increase in the use of immediate placement and loading in our private practice over the past 2 years is reflected by Figure 8.

The data collected as part of the clinical monitoring will be used at a later stage to report on long-term bone and soft tissue stability.

CONCLUSION

The survival rates described in this retrospective analysis are comparable

to those achieved with delayed loading protocols. They are also consistent with other studies, which demonstrate the efficacy of immediate placement and loading.

DISCLOSURE

The authors claim to have no financial interest, either directly or indirectly, in the products or information listed in the article. A. Sethi receives honoraria for specific lectures organized by Dentsply-Sirona.

APPROVAL

No systematic data collection beyond that which is part of routine clinical practice was performed and the retrospective analysis of the data therefore is exempt from IRB oversight as per letter of exemption from Chesapeake IRB (6940 Columbia Gateway Drive, Columbia, MD 21046).

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