Full-Mouth Rehabilitation Using a Tissue-Level Angled-Head Dental Implant System: A Retrospective Analysis with Long-Term Follow-Up

Adi Lorean, DMD[1]/Anahat Khehra, BMSc[2]/Jean Benatouil, DMD[3]/
Gideon Hallel, DMD, MPA[4]/Liran Levin, DMD, FRCD(C), FIADT, FICD[2]

Purpose: A new tissue-level implant design with angulations of 17, 30, and 45 degrees has been introduced to allow the use of the existing bone while maintaining the restorative platform at an angle to ensure an optimal functional and esthetic result for treatment of edentulous patients. The aim of this study was to measure implant survival, bone loss, and peri-implant health of the novel tissue-level angled-head dental implant system. ***Materials and Methods:*** A retrospective analysis of cases from three private offices that were using the new implant system was performed. Data regarding patients' demographics, number and location of implants, restoration type, bone loss, implant failure, bleeding, and pocket depths were collected and analyzed. The data collected were analyzed using mainly descriptive statistics. ***Results:*** A total of 29 participants were selected, and 185 dental implants were placed. The average patient age was 61 ± 7 years, and 52% were female. Some of the patients were medically compromised; 7% were diabetic, 20% were smokers, and 7% had osteoporosis. The average time from dental implant placement to the placement of the screw-retained crowns was 6 ± 5 months. Four implants failed with an average time to failure of 18 ± 8 months. Implant survival rate was 97.8%. The average bone loss was 0.014 ± 0.082 mm at 1 year, 0.133 ± 0.306 mm at 5 years, and 0.426 ± 0.903 mm at 10 years. Overall, 18.9% of implants were associated with bleeding, and only one implant had a pocket depth greater than or equal to 5 mm. ***Conclusion:*** The new tissue-level implant design with angulations of 17, 30, and 45 degrees has demonstrated predictable survival and success rates with minimal bone loss. The long-term follow-up seems highly promising; however, further studies are warranted to validate the results. *Int J Oral Maxillofac Implants 2022;37:685–689. doi: 10.11607/jomi.9433*

Keywords: alveolar bone, bone loss, peri-implantitis, success, survival

The use of dental implants for rehabilitation of edentulous sites is constantly rising.[1] Studies show that dental implants have a positive impact on quality of life, long-term survival rates, and low morbidity. A number of factors influence the treatment outcomes of implants. These include, among others, patients' habits, bone quality, implant location, surgical protocol, abutment connection, implant neck configuration, clinician's experience, and oral hygiene maintenance.[1,2] Furthermore, systemic conditions have an impact on healing and marginal bone loss.[3] For example, poorly controlled diabetes can put a patient at increased risk for peri-implantitis and implant failure.[4] If the diabetic condition is under control, then the placement of an implant has similar complication rates compared to placement in healthy patients. Osteoporosis can also negatively impact implant survival due to elevated levels of marginal bone loss in comparison to patients without osteoporosis.[5] Another factor that impairs healing ability is smoking.[6] It has been shown that smokers have an increased risk for postoperative infections, marginal bone loss, and implant failure.[6,7]

The treatment outcome for implant placement can be predicted based on not only a patient's medical history but also their oral hygiene habits. Home care and maintenance therapy are vital in the prevention of peri-implantitis.[8–11] In addition, implant design may have an effect on cleansability. There are two main implant neck configurations for the abutment connection.[12] The first is a bone-level implant. This variation usually has a rough surface all around and is completely inserted into the alveolar bone. From an esthetic point of view, complete insertion of the implant is ideal as the metal color

[1]Faculty of Medicine, Titu Maioresco University, Bucharest, Romania.
[2]Faculty of Medicine and Dentistry, University of Alberta, Alberta, Canada.
[3]Private practice, Herzelia, Israel.
[4]Private practice, Tel-Aviv, Israel.

The first two authors contributed equally to this study.

Correspondence to: Prof Liran Levin, Faculty of Medicine & Dentistry, School of Dentistry, University of Alberta, 5-468 Edmonton Clinic Health Academy, 11405 - 87 Avenue NW, 5th Floor, Edmonton AB T6G 1C9, Canada. Fax: +1-780-492-7536.
Email: liran@ualberta.ca

Submitted April 28, 2021; accepted July 16, 2021.

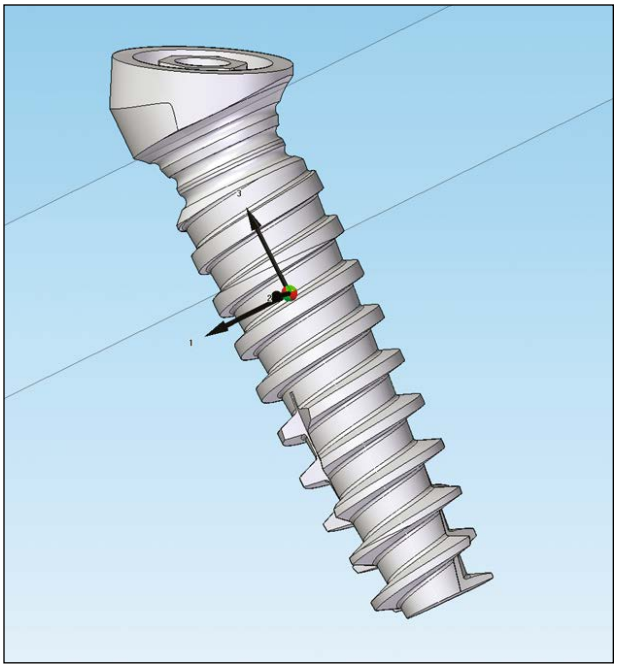

Fig 1 A novel tissue-level implant design with angulations of 17, 30, and 45 degrees.

is hidden.[13,14] However, it is usually more difficult for the patient to clean around the implant-abutment connection.[8] The second option, tissue-level implants, incorporate a smooth, polished area that is above the alveolar bone.[12] The location of the implant-abutment connection in tissue-level implants can be an advantage or disadvantage. The metal color of the implant may be visible and thus less desirable in anterior regions.[13] On the other hand, they are less challenging to clean and maintain for the patient because they are more accessible.[8] As a result, tissue-level implants may make the fight against bacteria and peri-implantitis an easier one.[9]

The angulation of the implant may also impact the restoration process, soft tissue response, and overall implant health.[8,15] To achieve the correct prosthetic and implant angulation might be challenging. Implant placement is guided by a number of factors, including bone volume, adjacent teeth, anatomical structures, and the soft tissue.[15,16] After an extraction, there is loss in both width and height of alveolar bone.[17] Therefore, the implant angulation will not always be ideal. The prosthetic component can be oriented to accommodate the implant angulation. However, soft tissue recession and increased marginal bone loss may result because of abutment positioning.[15,18] As well, in this situation, the crown will likely be cemented rather than screw-retained due to the angulation. A cemented crown increases the chance of peri-implantitis if cement residue is left behind.[8,19–21] Traditional tissue-level implants can further complicate the ability to change the angulation using an abutment.

To mitigate these potential issues, a novel tissue-level implant design with angulations of 17, 30, and 45 degrees has been introduced (Fig 1; Adin Dental Implant Systems). It is tilted to allow for the use of the existing bone while maintaining the restorative platform at an angle to ensure an optimal functional and esthetic result for treatment of edentulous patients. The study purpose was to evaluate implant survival, radiographic bone loss, and peri-implant health of the novel tissue-level angled-head dental implant system. It is hypothesized that implant survival of this new system will be similar to the rates found in the literature for other implant systems.

MATERIALS AND METHODS

The data collected in this retrospective study came from three private offices that were using the novel implant system for oral rehabilitation of edentulous patients. Three clinicians performed the implant placement and completed the follow-ups. All patients who had received the novel dental implants between the years 2008 and 2015 were included in the study. The data includes information on:

- Age (years)
- Sex (male, female)
- Smoking status at time of implant placement (yes, no)
- Diabetes mellitus at time of implant placement (yes, no)
- Osteoporosis at time of implant placement (yes, no)
- Date of implant placement (day/month/year)
- Time from placement to restoration (months)
- Jaw (maxilla, mandible)
- Implant position in jaw (tooth number)
- Radiographic bone loss (mm)
- Bleeding on probing (yes, no)
- Pocket depth (mm)
- Implant failure (yes, no)

Each patient received the same type of restoration, a screw-retained fixed denture. A Hu-Friedy UNC Probe was used in this study to evaluate peri-implant soft tissue health. The clinicians were calibrated using an automated force-controlled probe or a manual probe with 17 g of force. The bleeding percentage was calculated using the Gingival Bleeding Index.[22] At 1, 5, and 10 years after implant placement, radiographic bone level was evaluated using intraoral radiographs, and bone loss was also recorded. The implants threads were used as an internal standard for bone level calculation as previously described.[23–25] The radiographic marginal bone loss was measured mesial and distal to the implant.

Table 1 Number and Location of Implants and Timing of Implant Placement, Restoration, and Follow-Up

Patient	Number of implants received	Jaw	Time from placement to restoration (months)	Time from placement to last follow-up (months)
1	7	Maxilla	12	84
2	7	Mandible	2	100
3	8	Mandible	3	84
4	9	Maxilla	9	92
5	8	Maxilla	3	114
6	8	Mandible	5	114
7	8	Maxilla	8	116
	7	Mandible	14	108
8	6	Maxilla	7	105
9	6	Maxilla	11	125
10	6	Maxilla	3	118
11	8	Maxilla	12	83
12	8	Maxilla	8	98
13	8	Maxilla	8	91
	8	Mandible	8	94
14	8	Maxilla	14	84
15	8	Mandible	2	91
16	11	Maxilla	12	96
	6	Mandible	12	96
17	6	Maxilla	8	103
18	6	Mandible	22	111
19	8	Mandible	5	100
20	8	Maxilla	6	107
21	1	Maxilla	5	122
22	3	Mandible	0	129
23	2	Maxilla	5	65
24	1	Maxilla	0	61
25	1	Mandible	0	105
26	1	Mandible	0	123
27	1	Mandible	0	97
28	1	Mandible	0	50
29	1	Mandible	0	96

Data were collected in an Excel file and were analyzed using descriptive statistics in terms of average, standard deviations, and ranges. For assessment regarding the relationship between implant survival, marginal bone loss, and the confounding variables (smoking, diabetes, and osteoporosis), chi-square test was conducted.

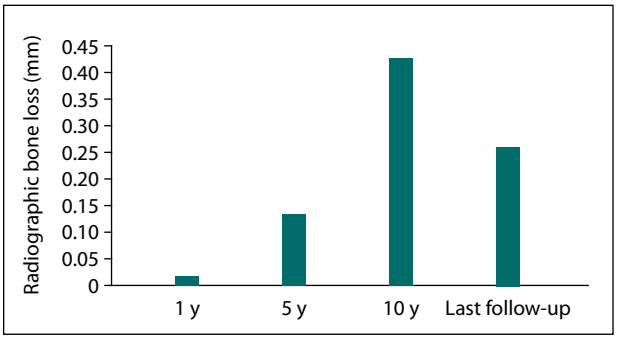

Fig 2 The radiographic bone loss at 1, 5, and 10 years after implant placement, as well as at the last follow-up appointment. The average bone loss was 0.014 ± 0.082 mm at 1 year, with a range from 0 to 0.5 mm; 0.133 ± 0.306 mm at 5 years, with a range from 0 to 1 mm; and 0.426 ± 0.903 mm at 10 years, with a range from 0 to 3 mm. The last follow-up appointment had an average bone loss of 0.260 ± 0.686 mm, with a range from 0 to 5 mm.

Statistical analysis was performed using SPSS software (Version 25.0, IBM).

RESULTS

A total of 29 participants were selected, and 185 dental implants were placed. The average age of patients was 61 ± 7 years, and 52% of patients were female. Some of the patients were medically compromised; 7% were diabetic, 20% were smokers, and 7% had osteoporosis. The number and location of the 185 implants placed per patient is presented in Table 1. A greater number of implants were placed in the maxilla (111) in comparison to the mandible (74). The time from placement of the implant to delivery of the final restoration varied between patients (range: 0 to 22 months). The average time to placement of the screw-retained crowns was 6 ± 5 months. The last follow-up appointment was at an average of 99 ± 13 months from the time of implant placement between 2008 and 2015.

The average bone loss after implant placement was 0.014 ± 0.082 mm at 1 year, 0.133 ± 0.306 mm at 5 years, and 0.426 ± 0.903 mm at 10 years (Fig 2). Bone loss varied in the first year from 0 to 0.5 mm. The range increased to 0 to 1 mm after 5 years and 0 to 3 mm after 10 years. The average bone loss at the last follow-up was 0.260 ± 0.686 mm. The range of bone loss was 0 to 5 mm (Fig 3). Implant loss as well as marginal bone loss around the implants was not found to be correlated to smoking habits, diabetes, or osteoporosis ($P > .05$). Four implant failures were seen, with an average time to failure of 18 ± 8 months. The presence of bleeding and pocket depths were noted at the last follow-up appointment. Thirty-five implants were associated with bleeding, and only one implant had a pocket depth greater than or equal to 5 mm.

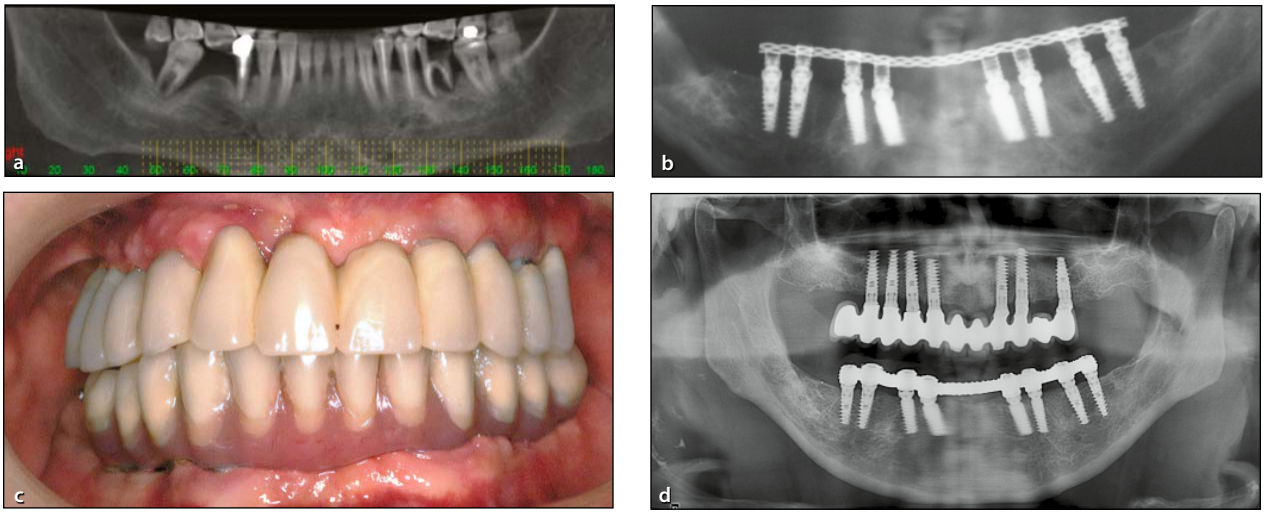

Fig 3 A representative case that was restored using the novel tissue-level angled-head dental implant system (mandible). *(a)* Preoperative radiographic view of the mandible. *(b)* Radiographic view immediately after placement of the implants and immediate restoration. *(c)* Clinical view of the final restoration. *(d)* Ten-year follow-up radiograph showing stable bone levels around the implants.

DISCUSSION

The study purpose was to evaluate implant survival, radiographic bone loss, and peri-implant health of the novel tissue-level angled-head dental implant system. It was hypothesized that implant survival of this new system would be similar to the rates found in the literature for other implant systems. To achieve functional and esthetic placement of an implant, a novel tissue-level implant design with angulations of 17, 30, and 45 degrees has been introduced. As mentioned previously, bone loss following extractions does not occur equally in all directions.[17] In order to maximize use of the existing bone and to account for the prosthetic connection, an angulated tissue-level implant may be used. A total of 185 angulated tissue-level dental implants in this long-term study showed a survival rate of 97.8% and a failure rate of 2.2% after a mean follow-up of 99 ± 13 months. In addition, the bone loss was minimal from the time of implant placement to the last follow-up appointment. The greatest bone loss was observed after 10 years of implant placement. Menini et al found that angulated implants were not associated with increased bone loss when compared to straight implants.[26] Aparicio et al identified the survival rates for tilted implants as 100% and for straight implants as 96.5%.[27] The use of angulated implants was found to be a suitable option in areas with mechanical and anatomical difficulties.

The success rates of angulated implants are also higher and associated with fewer complications compared with angulated abutments.[16,18] Omori et al found that angulated abutments were associated with greater marginal bone loss after 1 year compared to straight abutments.[18] In addition, screw and abutment loosening were frequent complications. The results showed that angulated abutments had increased implant failure rates that were statistically significant. An angulated implant might, therefore, be an effective and more favorable alternative to the use of angulated abutments.

In this study, smoking, diabetes, and osteoporosis as they relate to the patient's medical history were noted. Out of the four implant failures, only two were associated with the above diseases. Specifically, the two failures were associated with a single patient who had a history of smoking. Implant failure and marginal bone loss was not found to be correlated to smoking habits, diabetes, or osteoporosis, which might be attributed to the small number of failed implants and implants that demonstrated bone loss. Chen et al has reported that smokers have an increased risk for marginal bone loss and implant failure.[7] Studies have also shown the connection of implant survival with diabetes and osteoporosis.[3–5] The patient's medical condition is an important factor that has the ability to change healing, bone loss, and success rates. In this study, limited conclusions can be drawn between systemic diseases and implant success, as more data would be needed.

The overall limitations of this study include the use of retrospective data. No control was identified, and the selection of patients is subject to bias. The treatment was provided to those who require rehabilitation, and as a result, the patients were not chosen at random, and some confounding variables are not recognized. Many of the patients in the present study received more

than one implant, thus subjecting the study to cluster-correlated observations, which can increase the probability of implant failure among certain patients.[28] This is an important issue when evaluating and discussing dental implants; however, the relatively small number of failures and implants that presented with significant bone loss prevented further analysis of this phenomenon. The collection of data also relies on good record keeping and appropriate follow-up.

CONCLUSIONS

The new tissue-level implant design with angulations of 17, 30, and 45 degrees has demonstrated predictable survival and success rates with minimal bone loss. The long-term follow-up seems highly promising; however, further studies are warranted to validate the results.

ACKNOWLEDGMENTS

The authors declare no conflict of interest related to this study.

REFERENCES

1. Cosola S, Marconcini S, Boccuzzi M, et al. Radiological outcomes of bone-level and tissue-level dental implants: Systematic review. Int J Environ Res Public Health 2020;17:6920.
2. Griggs JA. Dental Implants. Dent Clin North Am 2017;61:857–871.
3. Compton SM, Clark D, Chan S, Kuc I, Wubie BA, Levin L. Dental implants in the elderly population: A long-term follow-up. Int J Oral Maxillofac Implants 2017;32:164–170.
4. Naujokat H, Kunzendrof B, Wiltfang J. Dental implants and diabetes mellitus—A systematic review. Int J Implant Dent 2016;2:5.
5. de Medeiros FCFL, Kudo GAH, Leme BG, et al. Dental implants in patients with osteoporosis: A systematic review with meta-analysis. Int J Oral Maxillofac Surg 2018;47:480–491.
6. Chrcanovic BR, Alberktsson T, Wennerberg A. Smoking and dental implants: A systematic review and meta-analysis. J Dent 2015;43:487–498.
7. Chen H, Liu H, Xu X, Qu X, Lu E. Smoking, radiotherapy, diabetes and osteoporosis as risk factors for dental implant failure: A meta-analysis. PLoS One 2013;8:71955.
8. Jepsen S, Berglundh T, Genco R, et al. Primary prevention of peri-implantitis: Managing peri-implant mucositis. J Clin Periodontol 2015;42(suppl 16):s152–s157.
9. French D, Ofec R, Levin L. Long term clinical performance of 10,871 dental implants with up to 22 years of follow-up: A cohort study in 4247 patients. Clin Implant Dent Relat Res 2021;23:289–297.
10. Sanz M, Bäumer A, Buduneli N, et al. Effect of professional mechanical plaque removal on secondary prevention of periodontitis and the complications of gingival and periodontal preventive measures: Consensus report of group 4 of the 11th European Workshop on Periodontology on effective prevention of periodontal and peri-implant diseases. J Clin Periodontol 2015;42:214–220.
11. Corbella S, Del Fabbro M, Taschieri S, De Siena F, Francetti L. Clinical evaluation of an implant maintenance protocol for the prevention of peri-implant diseases in patients treated with immediately loaded full-arch rehabilitations. Int J Dent Hyg 2011;9:216–222.
12. Serino G, Ström C. Peri-implantitis in partially edentulous patients: Association with inadequate plaque control. Clin Oral Implants Res 2009;20:169–174.
13. Siebert C, Rieder D, Eggert J, Wichmann MG, Heckmann SM. Long-term esthetic outcome of tissue-level and bone-level implants in the anterior maxilla. Int J Oral Maxillofac Implants 2018;33:905–912.
14. Wallner G, Rieder D, Wichmann MG, Heckmann SM. Peri-implant bone loss of tissue-level and bone-level implants in the esthetic zone with gingival biotype analysis. Int J Oral Maxillofac Implants 2018;33:1119–1125.
15. Vandeweghe S, Cosyn J, Thevissen E, Van den Berghe L, De Bruyn H. A 1-year prospective study on Co-Axis implants immediately loaded with a full ceramic crown. Clin Implant Dent Relat Res 2012;14:126–138.
16. Egbert N, Ahuja S, Selecman A, Wicks R. Angulated implants for fabrication of implant supported fixed partial denture in the maxilla. J Dent (Shiraz) 2017;18:304–313.
17. Van der Weijden F, Dell'Acqua F, Slot DE. Alveolar bone dimensional changes of post-extraction sockets in humans: A systematic review. J Clin Periodontol 2009;36:1048–1058.
18. Omori Y, Lang NP, Botticelli D, Papageorgiou AN, Baba S. Biological and mechanical complications of angulated abutments connected to fixed dental prostheses: A systematic review with meta-analysis. J Oral Rehabil 2020;47:101–111.
19. Schwarz F, Derks J, Monje A, Wang HL. Peri-implantitis. J Periodontol 2018;89:267–290.
20. Renvert S, Quiynen M. Risk indicators for peri-implantitis. A narrative review. Clin Oral Implants Res 2015;26:15–44.
21. Staubli N, Walter C, Schmidt JC, Weiger R, Zitzmann NU. Excess cement and the risk of peri-implant diseas—A systematic review. Clin Oral Implants Res 2017;28:1278–1290.
22. Lopes GDRS, Feitosa ACR, Suaid FF, et al. Evaluation of peri-implant condition in periodontally compromised patients. J Indian Prosthodont Soc 2019;19:283–289.
23. Levin L, Laviv A, Schwartz-Arad D. Long-term success of implants replacing a single molar. J Periodontol 2006;77:1528–1532.
24. Levin L, Hertzberg R, Har-Nes S, Schwartz-Arad D. Long-term marginal bone loss around single dental implants affected by current and past smoking habits. Implant Dent 2008;17:422–429.
25. Levin L, Nitzan D, Schwartz-Arad D. Success of dental implants placed in intraoral block bone grafts. J Periodontol 2007;78:18–21.
26. Menini M, Signori A, Tealdo T, et al. Tilted implants in the immediate loading rehabilitation of the maxilla: A systematic review. J Dent Res 2012;91:821–827.
27. Aparicio C, Perales P, Rangert B. Tilted implants as an alternative to maxillary sinus grafting: A clinical, radiologic, and Periotest study. Clin Implant Dent Relat Res 2001;3:39–49.
28. Schwartz-Arad D, Laviv A, Levin L. Failure causes, timing, and cluster behavior: An 8-year study of dental implants. Implant Dent 2008;17:200–207.