

Impact of Crown-Implant Ratio of Single Restorations Supported by 6-mm Implants: A Short-Term Case Series Study

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Purpose: High crown-implant ratios might affect the biologic and technical performance of a reconstruction. The aim of this study was to assess whether a higher crown-implant ratio of single restorations on 6-mm implants resulted in more peri-implant bone loss and more prosthetic complications during a 1-year follow-up period. **Materials and Methods:** A group of 37 patients were provided with 47 single-implant-supported restorations on 6-mm implants. Implants were placed in the posterior mandible or maxilla, where limited bone height was available. The clinical crown-implant ratio was determined on digitized casts. Peri-implant bone changes were analyzed on intraoral radiographs. Prosthetic complications were scored throughout the evaluation period. **Results:** The mean crown-implant ratio was 2.14 ± 0.42 . The mean peri-implant bone loss was 0.13 ± 0.36 mm. No complications occurred. **Conclusion:** High crown-implant ratios are not accompanied by increased peri-implant bone changes or prosthetic complications during a 1-year follow-up period. INT J ORAL MAXILLOFAC IMPLANTS 2016;31:672–675. doi: 10.11607/jomi.4092

Keywords: alveolar bone loss, crown-implant ratio, dental implants, fixed dental prosthesis, prospective study, single-tooth

Short endosseous implants from different implant brands have been reported in several studies with high success. Survival rates of implants shorter than 10 mm were shown to be similar to those of longer implants.^{1–5}

Inserting short implants can avoid the need of bone augmentation in the resorbed posterior region, but will lead consequently to a high crown-implant ratio.⁶ Systematic reviews by Blanes⁷ and Quaranta et al⁸ revealed that high crown-implant ratios did not have an impact on biologic outcomes, but could lead to prosthetic failures. The authors stated, however, that the included studies were reporting on various implant lengths and restoration designs, making interpretation and solid conclusions difficult. Moreover, short implants (≤ 7 mm) were not very well represented in their studies. In contrast, Malchiodi et al⁹ did find a significant correlation between implant success rates and the crown-implant ratio and between peri-implant bone loss and the crown-implant ratio. The critical threshold value of the clinical crown-implant ratio for avoiding excessive bone loss or implant failure was claimed to be 3.40. These ratios were found in clinical situations with very short implants. However, in that study, no distinction was made between splinted and nonsplinted restorations. Therefore, the aim of the present study was to assess whether a higher crown-implant ratio of single restorations on 6-mm implants resulted in more peri-implant bone loss and more prosthetic complications during a 1-year follow-up period.

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MATERIALS AND METHODS

The following groups were combined for the evaluation, making the study design a subanalysis of two independent prospective studies: from the study of Guljé et al,¹⁰ patients treated with 6-mm implants in the resorbed posterior maxilla; and from the study of Guljé et al,¹¹ patients treated with 6-mm implants in the resorbed posterior mandible.

Consecutive patients with one or more missing teeth in the posterior region of the maxilla or mandible and with an estimated bone height of 6 to 8 mm were included during a 2-year period. The study was approved by the Medical Ethical Committee of the University Medical Center Groningen, and written informed consent was collected from the patients. Each patient was planned to have at least one 6-mm implant (OsseoSpeed 4.0S implants, Dentsply) without any grafting. Implants were restored after a healing period of 3 months with custom-made titanium abutments (Atlantis Dentsply) and cemented zirconia-based porcelain crowns. Adjacent implant restorations were not connected. Intraoral radiographs were taken, using a standardized paralleling technique, 3 weeks after placement of the crown and 12 months thereafter (Fig 1). Technical complications were recorded during a 1-year evaluation period. Clinical crown-implant ratios were calculated on digitized casts as described by Meijer et al.¹² Dental casts with implant analog(s) and dental casts of antagonistic jaws were scanned with a three-dimensional (3D) scanner (3Shape D640, 3Shape A/S) and 3D scanning software (ScanItRestoration, 3Shape A/S). Models of the maxillary and mandibular dental cast were aligned in the proper occlusion. The occlusal contact point of the implant-supported crown and antagonistic arch were recorded intraorally during the patients' visit. This recorded contact point was used to define the position of the contact point on the digitized model. With a software program (DentalDesigner, 3Shape A/S), a two-point measurement was carried out: the shortest distance from the neck of the implant analog to the occlusal contact position on the antagonistic model. The crown-implant ratio was calculated by dividing this length by the known 6-mm length of the implant, with a correction for the actual height of the bone along the implant at the beginning of loading.

One observer analyzed the radiographs. Radiographs were made 2 weeks and 12 months after placement of the restoration. An individualized x-ray holder with parallel technique was used for standardization. The radiographs were analyzed with the software program DicomWorks (Biomedical Engineering, University Medical Center Groningen, the Netherlands) to perform linear measurements. Calibration was carried out in the vertical plane by using the known length of the implant, ensuring

correct measurement.¹³ Bone height was determined by measuring, both mesially and distally, the distance from the reference point (the junction between the machined bevel and the microthreads on the implant) to the level of crestal bone. If the implant reference point was below the margin of the crestal bone, ie, subcrestal, the value was considered as zero. Bone-level change was presented as the worst value for distal and/or mesial changes between 2 weeks and 12 months after crown placement for each implant. A frequency analysis for normal distribution was performed according to the Kolmogorov-Smirnov and Shapiro-Wilk tests. The means of the crown-implant ratios were compared using the analysis of variance (ANOVA). Regression analysis according to the Wald test had been performed on the association between crown-implant ratios and marginal bone change. A significance level of .05 was chosen.

RESULTS

A total of 37 patients to receive 47 implants were included (patient characteristics: 12 men, 25 women; mean age, 54 years (range, 30 to 71 years). All patients attended the 1-year follow-up period. Implant survival was 100% at the 12-month evaluation. Mean peri-implant bone loss was 0.13 ± 0.36 mm ($n = 47$), ie, 0.11 ± 0.21 mm ($n = 16$) for the maxilla and 0.14 ± 0.42 mm ($n = 31$) for the mandible. The mean crown-implant ratio was 2.14 ± 0.42 ($n = 47$; range, 1.16 to 3.23), ie, 1.95 ± 0.40 ($n = 16$) for the maxilla and 2.23 ± 0.40 ($n = 31$) for the mandible. No adverse prosthetic events occurred during the evaluation period. Logistic regression analyses according to the Wald test gave no association between the crown-implant ratio and peri-implant bone change for either the total group ($P = .875$), or the maxilla ($P = .690$) and mandible ($P = .957$) analyzed separately.

DISCUSSION

The study revealed no association between the crown-implant ratio and biologic or prosthetic complications with 6-mm implants and single restorations in the resorbed posterior region. In fact, no implants were lost, limited bone loss occurred, and prosthetic complications were not encountered.

Srinivasan et al¹⁴ reported a systematic review on 6-mm implants with an early cumulative survival rate of 93.7%. Implant failures observed were predominantly early failures (76%). Implant survival in the present study (100%) is better than in that systematic review.

Limited bone loss (mean: 0.13 mm) was detected during the 1-year evaluation period. A similar amount of bone loss was found in another study by Guljé and



Fig 1 Single restoration supported by a 6-mm implant in the maxilla (12 months after functional loading).

colleagues¹⁵ with the same implant system. Apparently, the connection of the implant and abutment, together with the platform switch, results in very limited bone-level change. This is in line with the results of the study of Telleman and coworkers on the effect of platform switching.^{16,17}

The present 1-year follow-up study also showed that no prosthodontic complications happened, which is in contrast with the expectation in the systematic reviews by Blanes and Quaranta et al.^{7,8} Apparently, the solid unit of implant and crown with a close connection between the implant and abutment prevented prosthetic complications.

Crowns of significant height have to be made on implants in arches with severe resorption, resulting in high crown-implant ratios. However, the maximum ratio allowed, as used for restorations on natural roots, might not apply to implant-supported restorations. Rokni and colleagues¹⁸ reported high crown-implant ratios: 1.0 for implants of 12 mm in length, 1.4 for 9-mm implants, 1.8 for 7-mm implants, and 2.6 for 5-mm implants. However, these authors reported no association between the crown-implant ratios and peri-implant bone loss. The findings in the present study are also in support of the conclusions drawn by Blanes and Quaranta et al.^{7,8} crown-implant ratios of implant-supported reconstructions do not influence peri-implant crestal bone loss. Crown-implant ratios in the present study varied from 1.16 to 3.23. None of the ratios exceeded the critical threshold value of 3.40 as advocated by Malchiodi et al,⁹ meaning that this statement could not be confirmed. In a study by Meijer et al,¹² the crown-implant ratio calculated on intraoral radiographs appeared to be significantly higher than the crown-implant ratio calculated on digitized casts. Since the method applying digitized casts uses the functional contact point with an antagonistic tooth, this crown

length can be considered to be more realistic than a crown length measured on a radiograph. Moreover, the actual contact point cannot be seen on a radiograph, and the most coronal part of the crown could in fact not be the point of the crown that is in function: static and dynamic contact points may be on another surface area of the crown than at the top of the highest cusp. The present 1-year follow-up study also showed that no prosthodontic complications happened, which is in contrast with the expectation in the systematic reviews by Blanes and Quaranta et al.^{7,8} It needs to be mentioned that the 1-year evaluation is a very short time to evaluate the impact of the crown-implant ratio. One can imagine that a high loading force on a short implant, with limited bone-to-implant contact, exerts its influence over time and is therefore not noticed after 1 year. Also, 47 implants in the study is a limited sample size. Medium-term and long-term evaluation is needed to endorse the findings of the present study. Although augmentation procedures are considered to be reliable procedures, complications have been reported.¹⁹ Avoiding this procedure means lower morbidity, risk, and costs. If proven reliable in the long term, short implants may become the treatment of choice for the posterior resorbed maxilla and mandible, since short implants may offer greater simplicity and safety. Also, the total costs of the treatment are lower.

CONCLUSIONS

Within the limitations of this study, it can be concluded that high crown-implant ratios are not accompanied by increased peri-implant bone changes or prosthetic complications.

ACKNOWLEDGMENTS

This research was supported by the authors' institution. The authors declare that there is no conflict of interest.

REFERENCES

1. Renouard F, Nisand D. Short implants in the severely resorbed maxilla: A 2-year retrospective clinical study. *Clin Implant Dent Relat Res* 2005;7:S104–S110.
2. Pommer B, Frantal S, Willer J, et al. Impact of dental implant length on early failure rates: A meta-analysis of observational studies. *J Clin Periodontol* 2011;38:856–863.
3. Telleman G, Raghoobar GM, Vissink A, et al. A systematic review of the prognosis of short (<10 mm) dental implants placed in the partially edentulous patient. *J Clin Periodontol* 2011;38:667–676.
4. Annibaldi S, Cristalli MP, Dell'Aquila D, et al. Short dental implants: A systematic review. *J Dent Res* 2012;91:25–32.
5. Mezzomo LA, Miller R, Trichet D, Alonso F, Shinkai RS. Meta-analysis of single crowns supported by short (<10mm) implants in the posterior region. *J Clin Periodontol* 2014;41:191–213.

6. Guljé F, Abrahamsson I, Chen S, et al. Implants of 6mm vs. 11mm lengths in the posterior maxilla and mandible: A 1-year multicenter randomized controlled trial. *Clin Oral Implants Res* 2013;24:1325–1331.
7. Blanes RJ. To what extent does the crown-implant ratio affect survival and complications of implant-supported reconstructions? A systematic review. *Clin Oral Implants Res* 2009;20:567–572.
8. Quaranta A, Piemontese M, Rappelli G, Sammartino G, Procaccini M. Technical and biological complications related to crown to implant ratio: A systematic review. *Implant Dent* 2014;23:180–187.
9. Malchiodi L, Cucchi A, Ghensi P, Consonni D, Nocini PF. Influence of crown-implant ratio on implant success rates and crestal bone levels: A 36-month follow-up prospective study. *Clin Oral Implants Res* 2014;25:240–251.
10. Guljé FL, Raghoobar GM, Vissink A, Meijer HJA. Single crowns in the resorbed posterior maxilla supported by either 6-mm implants or by 11-mm implants combined with sinus floor elevation surgery: A 1-year randomized controlled trial. *Eur J Oral Implantol* 2014;7:247–255.
11. Guljé FL, Raghoobar GM, Vissink A, Meijer HJA. Single restorations in the resorbed posterior mandible supported by 6-mm implants: A 1-year prospective case series study. *Clin Implant Dent Relat Res* 2015;17:e465–e471.
12. Meijer HJ, Telleman G, Gareb C, et al. Comparison of implant-supported crown length measured on digitized casts and intraoral radiographs. *Int J Prosthodont* 2012;25:357–359.
13. Sewerin IP. Errors in radiographic assessment of marginal bone height around osseointegrated implants. *Scand J Dent Res* 1990;98:428–433.
14. Srinivasan M, Vazquez L, Rieder P, et al. Survival rates of short (6 mm) micro-rough surface implants: A meta-analysis. *Clin Oral Implants Res* 2014;25:539–545.
15. Guljé F, Abrahamsson I, Chen S, et al. Implants of 6mm vs. 11mm lengths in the posterior maxilla and mandible: A 1-year multicenter randomized controlled trial. *Clin Oral Implants Res* 2013;24:1325–1331.
16. Telleman G, Raghoobar GM, Vissink A, Meijer HJ. Impact of platform switching on inter-proximal bone levels around short implants in the posterior region; 1-year results from a randomized clinical trial. *J Clin Periodontol* 2012;39:688–697.
17. Telleman G, Meijer HJ, Vissink A, Raghoobar GM. Short implants with a nanometer-sized CaP surface provided with either a platform-switched or platform-matched abutment connection in the posterior region: A randomized clinical trial. *Clin Oral Implants Res* 2013;24:1316–1324.
18. Rokni S, Todescan R, Watson P, et al. An assessment of crown-to-root ratios with short sintered porous-surfaced implants supporting prostheses in partially edentulous patients. *Int J Oral Maxillofac Implants* 2005;20:69–76.
19. Lee HW, Lin WS, Morton D. A retrospective study of complications associated with 100 consecutive maxillary sinus augmentations via the lateral window approach. *Int J Oral Maxillofac Implants* 2013;3:860–868.