Journal of Oral Rehabilitation

Journal of Oral Rehabilitation 2015 **42**; 153–161

Review

Occlusion on oral implants: current clinical guidelines

K. KOYANO & D. ESAKI *Section of Implant and Rehabilitative Dentistry, Division of Oral Rehabilitation, Faculty of Dental Science, Kyushu University, Fukuoka, Japan*

SUMMARY **Proper implant occlusion is essential for adequate oral function and the prevention of adverse consequences, such as implant overloading. Dental implants are thought to be more prone to occlusal overloading than natural teeth because of the loss of the periodontal ligament, which provides shock absorption and periodontal mechanoreceptors, which provide tactile sensitivity and proprioceptive motion feedback. Although many guidelines and theories on implant occlusion have been proposed, few have provided strong supportive evidence. Thus, we performed a narrative literature review to ascertain the influence of implant occlusion on the occurrence of complications of implant treatment and discuss the clinical considerations focused on the overloading factors at present. The search terms were 'dental implant', 'dental implantation', 'dental occlusion' and 'dental prosthesis'. The inclusion criteria were literature published in English up to September 2013. Randomised controlled trials (RCTs), prospective cohort studies and case–control studies with at least 20 cases and 12 months follow-up interval were included. Based on the selected literature, this review explores factors related to the implant prosthesis (cantilever, crown/implant ratio, premature contact, occlusal scheme, implant–abutment connection, splinting implants and tooth–implant connection) and other considerations, such as the number, diameter, length and angulation of implants. Over 700 abstracts were reviewed, from which more than 30 manuscripts were included. We found insufficient evidence to establish firm clinical guidelines for implant occlusion. To discuss the ideal occlusion for implants, further well-designed RCTs are required in the future.**

KEYWORDS: **dental implants, dental occlusion, evidence-based dentistry, clinical guideline, dental prosthesis, clinical trial**

Accepted for publication 30 August 2014

Introduction

Dental implants have been extensively used for oral reconstruction of partial and complete edentulism. Although many clinical studies have shown high success rates with dental implant treatments (1–4), several studies have reported failures and complications for diverse reasons. One of these reasons is overloading resulting from improper occlusion (5). Overloading refers to stress around the implant components and bone–implant interface that is not biologically acceptable. Dental implants frequently suffer from occlusal overload because the prostheses lack the supporting periodontal ligaments that are known to provide the shock-absorbing function of natural teeth. Additionally, dental implants exhibit low tactile sensitivity and low proprioceptive motion feedback because of the absence of periodontal mechanoreceptors (6). Therefore, it was said that conventional occlusal concepts must be modified to reduce the occlusal force on implant prostheses and offer some protection. Some examples of these changes include narrowed occlusal table, reduced cuspal inclination, correction of load direction, reduced non-axial loading, reduced length of the cantilever and lighter occlusal contacts on implant prostheses (7). Misch

doi: 10.1111/joor.12239

proposed that occlusal adjustments are necessary to eliminate mobility differences between the implants and the teeth during heavy biting (8). Furthermore, Rangart *et al.* (9) reported that regular re-evaluation and periodic occlusal adjustments were necessary to prevent the potential overload that occurs with the positional changes of natural teeth. There are currently numerous guidelines and theories that indicate concrete occlusal schemes along with variations in dentition and the types of prosthesis used to obtain proper implant occlusion. Although all of these propositions appear to be practical for the clinical setting, they are not sufficiently supported by research based on clinical outcomes. The ideal implant occlusion would allow controlled stress around the implant components, provide a prosthetically and biologically acceptable bone–implant interface and obtain long-term stability of the marginal bone and prosthesis. However, it is not clear that the occlusion for oral implants needs to differ from that in the natural dentition. Here, we undertook a narrative literature review to seek the influence of implant occlusion on the occurrence of complications in implant treatment and to discuss the clinical considerations associated with overloading factors.

Methods

A search of English language literature was conducted to examine the existing scientific evidence for the current clinical guidelines and strategies for implant occlusion using Medline/PubMed (http://www.ncbi.nlm.nih.gov/pubmed) in September 2013. The search terms were 'dental implant', 'dental implantation', 'dental occlusion' and 'dental prosthesis'. Abstracts of the following types of articles were reviewed: Randomised controlled trials (RCTs), prospective cohort studies and case–control studies that included at least 20 cases and 12 months follow-up interval. Furthermore, literature was also selected that examined aspects of implant occlusion such as the implant prosthesis factors (cantilever, crown/implant ratio, implant–abutment connection, splinting implants and tooth–implant connection) and factors pertaining to the dimensions of the implant (diameter, length and angulation of implants) or number of implants used in the case and had evaluated either of the following aspects: biological complications (marginal bone level and implant survival rate, e.g.: the presence of the implant in the oral cavity regardless of marginal bone loss) or mechanical complications (prosthesis survival rate, component fracture and screw loosening). Over 700 abstracts were reviewed, from which more than 30 manuscripts, which were related to the overloading factors of implant occlusion, were included (Table 1). In this review, large sample sizes were defined as over 50 mean patients, and long observation periods were defined as over 60 months mean observation period.

Results

Number of implants

Implant-retained overdenture for edentulous jaws. Seven studies (10–16) were selected to determine whether there is a difference in the marginal bone level and implant survival rate between the use of two or more implants in fully edentulous patients with an implant-retained overdenture (Table 2). Additionally, the marginal bone level and survival rates were evaluated between the bar and ball systems, as determined based on 2 RCTs (17, 18) (Table 3).

In mandibular reconstructions, the marginal bone level and implant survival rates are not significantly different for two implants with a bar, two implants with ball attachments and four implants with a bar, based on 6 RCTs (10–15) with large sample sizes and long observation periods. The marginal bone level and implant survival rates are not significantly different between bar and ball attachments based on 2 RCTs (17, 18) with small sample sizes and long observation periods. Because of the high bone density, it is

Table 1. Reviewed issues regarding the overloading factors of implant occlusion

Implant	
Number of implants	[14]
Implant diameter	[3]
Implant angulation	[2]
Prosthesis	
Cantilevers	[4]
Crown/Implant ratio	[1]
Implant–abutment connection	[0]
Cement or screw retained reconstruction	[0]
Implant–tooth connection	[4]
Timing of loading	[8]

Table 2. Selected studies concerning the number of implants in overdentures

Authors	Year of publication	Study design	Sample size (patients)	Observation period (months)	Region	Anchorage system	Implant survival rate (%)	Marginal bone level
Batenburg *et al.* (10)	1998	RCT	58	12	Mandible	2 implant bar/ 4 implant bar	99·9	No statistically significant differences
Wismeijer *et al.* (11)	1999	RCT	102	19	Mandible	2 implant ball/2 implant bar/ 4 implant bar	100	No statistically significant differences
Visser *et al.* (12)	2005	RCT	56	60	Mandible	2 implant bar/4 implant bar	99·9	No statistically significant differences
Meijer *et al.* (13)	2009	RCT	50	120	Mandible	2 implantbar/4 implant bar	95/100	No statistically significant differences
Kronstrom *et al.* (14)	2010	RCT	33	12	Mandible	1 implantball/2 implant ball	81·8	No statistically significant differences
Stoker *et al.* (15)	2012	RCT	110	99	Mandible	2 implant ball/2 implant bar/ 4 implant bar	95·3/100/100	Patients with two implants show less marginal bone loss than those with four implants
Slot *et al.* (16)	2013	RCT	49	12	Maxilla	4 implant bar/ 6 implant bar	99·3/100	No statistically significant differences

possible to obtain good results with an implant-retained overdenture in the mandible with a minimum of two implants positioned between the right and left mental foramina.

In maxillary reconstructions, the marginal bone level and implant survival rates are not significantly different for four or six implants with bars; however, this is based on only 1 RCT (16) that had a small sample size ($n = 49$) and a short observation period (12 months). This RCT indicated that a minimum of four implants is necessary to retain the maxillary overdenture.

Fixed prostheses for edentulous jaws. Five studies (19–23) were selected to determine whether there is a difference in the marginal bone level between four or more implants in fully edentulous patients with implant-supported fixed prostheses (Table 4).

In mandibular reconstructions, there is no difference between four or more implants in terms of marginal bone level and survival rates based on 3 RCTs (19, 21, 22) with large sample sizes and long observation periods.

In maxillary reconstructions, there is no difference between four or six implants in terms of marginal bone level and survival rates for maxillary surgeries, based on 2 RCTs (20, 23) with small sample sizes and short observation periods.

Fixed prostheses for partially edentulous jaws. Neither RCT nor other prospective study was found directly comparing the number of implants in partially edentulous conditions. One controlled clinical trial (24) was selected to determine whether there is a difference in the marginal bone level between the splint and non-splint group in the partially edentulous posterior maxilla. In this study, 44 patients received three adjacent implants with splinted or non-splinted cement-retained fixed prostheses, observed over 60 months. There was no statistically significant difference between the groups in the mean marginal bone level at the 5-year recall.

Implant diameter

Three studies (25–27) were selected to determine whether there is a difference in the marginal bone level between wide diameters or other diameter implants (Table 5).

Table 3. Selected studies concerning the anchorage system in overdentures

Authors	Year of publication	Study design	Sample size (patients)	Observation period (month)	Region	Attachment	Marginal bone level
Jofré *et al.* (17)	2010	RCT	45	15	Mandible	2 implant bar/ 2 implant ball	statistically significant differences
Naert *et al.* (18)	2004	RCT	36	120	Mandible	2 implant bar/2 implant ball/ 2 implant magnet	No statistically significant differences

Based on 3 prospective cohort studies with large sample sizes and long observation periods, the diameter of the implants did not seem to influence implant survival rate.

Implant angulation

No RCT was found directly comparing angulation of implants. Two prospective studies (28, 29) were selected to determine whether there is a difference in the marginal bone level between vertical and angulated implant placements in maxillary reconstructions (Table 6).

When bone resorption is severe, it is impossible to place an implant in the ideal position beneath the prosthesis, thus requiring angulation. No difference in implant and prostheses survival rate was determined with large sample sizes and short observation periods. In terms of reducing the invasiveness of the implantation in older patients, the use of angulated implant placement could be an effective option.

Cantilevers

Four prospective cohort studies (30–33) were selected to determine whether there is a difference in the marginal bone loss for reconstruction with and without cantilevers (Table 7).

In cases where anatomical constraints make it difficult to place the implant, the prosthesis may comprise cantilever extensions. Based on 4 RCTs with small sample sizes and long observation periods, no difference in marginal bone level between reconstruction with or without cantilevers was reported; however, technical complications were frequently observed with cantilevers than without cantilevers. Therefore, prostheses with cantilevers should be checked not only for changes in the marginal bone level, but also for screw loosening or other changes in the occlusal contact and vertical dimension of the prosthesis.

Crown/implant ratio

One prospective cohort study (34) was selected to determine whether there is a difference in the marginal bone level with regard to the crown–implant ratio.

During bone resorption, the clearance between the opposing teeth and/or the alveolar ridge is increased. This leads to an imbalance between the length of the implant and the prosthesis. No significant difference in marginal bone level with regard to crown–implant ratio was found with a large sample size (n = 109) and short observation period (53 months) (34). The current available evidence suggests that the crown/implant ratio does not affect marginal bone level.

Implant–abutment connection

No RCT or other prospective studies that directly compare internal and external connections could be found. Gracis *et al.* (35) performed a meta-analysis to assess screw loosening among other factors using 4 RCTs, 13 prospective and 2 retrospective studies. Implant–abutment connection systems are broadly classified into two categories: external and internal connections, and they reported that screw loosening was likely to occur with external connections rather than with internal connections.

Cement- or screw-retained reconstruction

No RCT or other prospective studies that directly compared cement- and screw-retained reconstructions could be identified in this review. Sailer *et al.* (36) reviewed 3 RCTs and 11 prospective studies that partly included information on this topic. They found

Table 4. Selected studies concerning the number of implants in fixed prostheses

Authors	Year of publication	Study design	Sample size (patients)	Observation period (months)	Region	Number of implants	Marginal bone level	Implant survival rate (%)	Prostheses' survival rate (%)
Eliasson *et al.* (19)	2000	Prospective cohort	60	119	Mandible	4 implants	−0·5 mm (after 5 years)	98·6	99·1
Jemt *et al.* (20)	2002	Prospective cohort	60	58	Maxilla	≥5 implants	No statistically significant differences	91·4, 94	94·9, 95·6
Eliasson (21)	2008	Prospective cohort	119	178	Mandible	6 implants	Not recorded	99·4	97·7
Malo *et al.* (22)	2011	Prospective cohort	245	120	Mandible	4 implants	Not recorded	94·8	99·2
Malo *et al.* (23)	2011	Prospective cohort	60	221	Maxilla	4 implants	Not recorded	95·8	98·6

that cement-retained reconstructions exhibited more serious biological complications. They found that 2·8% of patients had a marginal bone level of >2 mm in cement-retained crowns as compared with 0% for screw-retained crowns over a 5-year period. Comparatively, however, the screw-retained reconstructions exhibited more technical problems, with an estimated 5-year incidence of technical complications of 24·4% as compared with the 11·9% for cement-retained crowns. Both types of reconstruction had a negative effect on the clinical outcomes, with neither method clearly advantageous over the other.

Tooth–implant connection

Four RCTs (37–40) were selected to determine whether there is a difference in the marginal bone level between studies where a connection was made between the implant and natural tooth or not (Table 8).

No significant differences in marginal bone level were found between cases with or without connection between the implant and natural tooth based on 3 RCTs with small sample sizes and long observation periods. However, there was a high incidence of intrusion based on 1 RCT with small sample sizes and long observation periods. Implants exhibit different displacement characteristics in response to loading when compared with natural teeth. Thus, in cases where tooth–implant connection is required, it is necessary to carefully monitor for intrusion of the natural tooth.

Timing of loading

Eight RCTs (41–48) were selected to determine whether there is a difference in the marginal bone level between immediate, early and conventional loading of implants (Table 9).

Advances in basic and clinical research have led to improvements in surgical techniques, in the design of fixtures and in the characteristics of implant surfaces, resulting in a shortened healing period, with different loading protocols selected for different patients. There was no significant difference between immediate, early and conventional loading of implants in terms of marginal bone level as well as implant survival rates in RCTs with large sample sizes and short observation periods.

Table 5. Selected studies concerning the diameter of implants

Authors	Year of publication	Study design	Sample size (patients)	Observation period (months)	Implant survival rate
Lekholm *et al.* (25)	1999	Prospective cohort	127	120	No statistically significant differences
Romeo *et al.* (26)	2004	Prospective cohort	250	16–84	No statistically significant differences
Lemmerman *et al.* (27)	2005	Prospective cohort	376	63·6	No statistically significant differences

Table 6. Selected studies concerning the angulation of implants

Authors	Year of publication	Study design	Sample size (patients)	Observation period (month)	Marginal bone level	Prosthesis survival rate
Sethi *et al.* (28)	2005	Prospective cohort	476	60	Not recorded	No statistically significant differences
Tabrizi *et al.* (29)	2013	Prospective cohort	58	36·7 ± 1·4	No statistically significant differences	Not recorded

Table 7. Selected studies concerning the cantilevers of implant prostheses

Authors	Year of publication	Study design	Sample size (patients)	Observation period (months)	Marginal bone level	Mechanical complication
Wennström *et al.* (30)	2004	Prospective cohort	28	60	Not recorded	No statistically significant differences
Brägger *et al.* (31)	2005	Prospective cohort	14	112·8	Not recorded	Statistically significant differences
Kreissl *et al.* (32)	2007	Prospective cohort	20	60	Not recorded	Statistically significant differences
Romeo *et al.* (33)	2009	Prospective cohort	59	96	No statistically significant differences	Statistically significant differences

Table 8. Selected studies concerning the implant–tooth connection

Authors	Year of publication	Study design	Sample size (patients)	Observation period (months)	Marginal bone level	Prosthesis survival rate
Olsson *et al.* (37)	1995	RCT	23	60	No statistically significant differences	No statistically significant differences
Gunne *et al.* (38)	1999	RCT	23	120	No negative influences	No negative influences
Block *et al.* (39)	2002	RCT	40	60	No statistically significant differences	High incidence of intrusion (66%)
Mau *et al.* (40)	2002	RCT	313	60	No statistically significant difference	No statistically significant difference

Discussion

Although there are numerous studies concerning implant occlusion, most demonstrate poor study design and ambiguous results and are thus possibly unreliable. In an earlier review, we reported that many studies regarding the stomatognathic function of specific occlusal schemes are of low quality because of poor study design, with little scientific evidence to support that one specific occlusal scheme is superior

Table 9. Selected studies concerning the timing of loading

Authors	Year of publication	Study design	sample size (patients)	Observation period (months)	Loading protocol	Marginal bone level
Hall *et al.* (41)	2006	RCT	27	12	Immediate restoration / Conventional load	No statistically significant differences
Crespi *et al.* (42)	2008	RCT	40	24	Immediate load / Conventional load	No statistically significant differences
Galli *et al.* (43)	2008	RCT	52	12	Immediate restoration/ Eary load	No statistically significant differences
Ganeles *et al.* (44)	2008	RCT	266	12	Immediate restoration / Earty load	No statistically significant differences
Güncü *et al.* (45)	2008	RCT	23	12	Immediate load / Conventional load	No statistically significant differences
Schincaglia *et al.* (46)	2008	RCT	29	12	Immediate load / Conventional load	Statisticallyy significant differences
Degidi *et al.* (47)	2009	RCT	60	12	Immediate restoration/ Conventional load	No statistically significant differences
Prosper *et al.* (48)	2010	RCT	71	60	Immediate load/ Conventional load	No statistically significant differences

to another in terms of its clinical outcome, such as longer survival of the prosthesis/residual teeth, periodontal breakdown, tooth/prosthesis wear, chewing efficiency, and bony change in the TMJ, among others (49). Few studies have actually sought to compare the difference in guidance applied to the implant. The aforementioned study (34) found no significant difference in marginal bone level with regard to occlusal table width. Another prospective cohort study with a large sample size ($n = 56$) and short observation period (2–3 months) (50) compared the difference between canine guidance, group function and balanced occlusion. They found that canine guidance is a risk factor for gold screw loosening. Comparatively, Carlsson *et al.* (51) reported that the principles and methods applied in conventional prosthodontics can, in general, be used also for implant prostheses. Within the literature, there is relatively reliable scientific evidence concerning the number of implants and timing of loading that can be followed to obtain successful results with dental implants. Despite these findings, the review was overall unable to identify a specific occlusal scheme for implant occlusion from the current body of literature that provides successful results with sufficient scientific support.

Conclusion

There was insufficient evidence to establish clinical guidelines for implant occlusion. Further well-designed RCTs are required in the future. Implant occlusion should be examined not only in terms of conventional occlusal schemes but also from the standpoint of the role of overloading factors. These are the factors related to the load-bearing function by marginal bone as well as implant components.

Disclosure

This research was carried out without funding, and no conflicts of interest are declared.

References

1. Örtorp A, Jemt T. Early laser-welded titanium frameworks supported by implants in the edentulous mandible: a 15-year comparative follow-up study. Clin Implant Dent Relat Res. 2009;11:311–322.
2. Romeo E, Ghisolfi M, Rozza R, Chiapasco M, Lops D. Short (8-mm) dental implants in the rehabilitation of partial and complete edentulism: a 3- to 14-year longitudinal study. Int J Prosthodont. 2006;19:586–592.
3. Wennström JL, Ekestubbe A, Gröndahl K, Karlsson S, Lindhe J. Implant-supported single-tooth restorations: a 5-year prospective study. J Clin Periodontol. 2005;32:567–574.
4. Andersson B, Glauser R, Maglione M, Taylor Å. Ceramic implant abutments for short-span FPDs: a prospective 5-year multicenter study. Int J Prosthodont. 2003;16:640–646.
5. Esposito M, Hirsch J, Lekholm U, Thomsen P. Differential diagnosis and treatment strategies for biologic complications and failing oral implants: a review of the literature. Int J Oral Maxillofac Implants. 1999;14:473–490.

6. Adell R. Tissue integrated prostheses in clinical dentistry. Int Dent J. 1985;35:259–265.
7. Lundgren D, Laurell L. Biomechanical aspects of fixed bridgework supported by natural teeth and endosseous implants. Periodontology. 2000;1994:23–40.
8. Misch CE. Implant design considerations for the posterior regions of the mouth. Implant Dent. 1999;8:376–386.
9. Rangert BR, Sullivan RM, Jemt TM. Load factor control for implants in the posterior partially edentulous segment. Int J Oral Maxillofac Implants. 1997;12:360–370.
10. Batenburg RH, Raghoebar GM, Van Oort RP, Heijdenrijk K, Boering G. Mandibular overdentures supported by two or four endosteal implants. A prospective, comparative study. Int J Oral Maxillofac Surg. 1998;27:435–439.
11. Wismeijer D, van Waas MA, Mulder J, Vermeeren JI, Kalk W. Clinical and radiological results of patients treated with three treatment modalities for overdentures on implants of the ITI Dental Implant System. A randomized controlled clinical trial. Clin Oral Implant Res. 1999;10:297–306.
12. Visser A, Raghoebar GM, Meijer HJA, Batenburg RHK, Vissink A. Mandibular overdentures supported by two or four endosseous implants: a 5-year prospective study. Clin Oral Implant Res. 2005;16:19–25.
13. Meijer HJA, Raghoebar GM, Batenburg RHK, Visser A, Vissink A. Mandibular overdentures supported by two or four endosseous implants: a 10-year clinical trial. Clin Oral Implant Res. 2009;20:722–728.
14. Kronstrom M, Davis B, Loney R, Gerrow J, Hollender L. A prospective randomized study on the immediate loading of mandibular overdentures supported by one or two implants: a 12-month follow-up report. Int J Oral Maxillofac Implants. 2010;25:181–188.
15. Stoker G, van Waas R, Wismeijer D. Long-term outcomes of three types of implant-supported mandibular overdentures in smokers. Clin Oral Implant Res. 2012;23:925–929.
16. Slot W, Raghoebar GM, Vissink A, Meijer HJ. Maxillary overdentures supported by four or six implants in the anterior region; 1-year results from a randomized controlled trial. J Clin Periodontol. 2013;40:303–310.
17. Jofré J, Hamada T, Nishimura M, Klattenhoff C. The effect of maximum bite force on marginal bone loss of mini-implants supporting a mandibular overdenture: a randomized controlled trial. Clin Oral Implant Res. 2010;21:243–249.
18. Naert I, Alsaadi G, van Steenberghe D, Quirynen M. A 10-year randomized clinical trial on the influence of splinted and unsplinted oral implants retaining mandibular overdentures: peri-implant outcome. Int J Oral Maxillofac Implants. 2004;19:695–702.
19. Eliasson A, Palmqvist S, Svenson B, Sondell K. Five-year results with fixed complete-arch mandibular prostheses supported by 4 implants. Int J Oral Maxillofac Implants. 2000;15:505–510.
20. Jemt T, Bergendal B, Arvidson K, Bergendal T, Karlsson LD, Linden B *et al.* Implant-supported welded titanium frameworks in the edentulous maxilla: a 5-year prospective multicenter study. Int J Prosthodont. 2002;15:544–548.
21. Eliasson A. On the role of number of fixtures, surgical technique and timing of loading. Swed Dent J Suppl. 2008;197:3–95.
22. Malo P, de Araujo Nobre M, Lopes A, Moss SM, Molina GJ. A longitudinal study of the survival of All-on-4 implants in the mandible with up to 10 years of follow-up. J Am Dent Assoc. 2011;142:310–320.
23. Malo P, Nobre M, Lopes A. The rehabilitation of completely edentulous maxillae with different degrees of resorption with four or more immediately loaded implants: a 5-year retrospective study and a new classification. Eur J Oral Implantol. 2011;4:227–243.
24. Vigolo P, Zaccaria M. Clinical evaluation of marginal bone level change of multiple adjacent implants restored with splinted and nonsplinted restorations: a 5-year prospective study. Int J Oral Maxillofac Implants. 2010;25:1189–1194.
25. Lekholm U, Gunne J, Henry P, Higuchi K, Linden U, Bergström C *et al.* Survival of the Branemark implant in partially edentulous jaws: a 10-year prospective multicenter study. Int J Oral Maxillofac Implants. 1999;1:639–645.
26. Romeo E, Lops D, Margutti E, Ghisolfi M, Chiapasco M, Vogel G. Long-term survival and success of oral implants in the treatment of full and partial arches: a 7-year prospective study with the ITI dental implant system. Int J Oral Maxillofac Implants. 2004;19:247–259.
27. Lemmerman KJ, Lemmerman NE. Osseointegrated dental implants in private practice: a long-term case series study. J Periodontol. 2005;76:310–319.
28. Sethi A, Kaus T, Sochor P. The use of angulated abutaments in implant dentistry: five-year clinical results of an ongoing prospective study. Int J Oral Maxillofac Implants. 2000;15:801–810.
29. Tabrizi R, Pourdanesh F, Zare S, Daneste H, Zeini N. Do angulated implants increase the amount of bone loss around implants in the anterior maxilla? J Oral Maxillofac Surg. 2013;71:272–277.
30. Wennström J, Zurdo J, Karlsson S, Ekestubbe A, Gröndahl K, Lindhe J. Bone level change at implant-supported fixed partial dentures with and without cantilever extension after 5 years in function. J Clin Periodontol. 2004;31:1077–1083.
31. Brägger U, Karoussis I, Persson R, Pjetursson B, Salvi G, Lang NP. Technical and biological complications/failures with single crowns and fixed partial dentures on implants: a 10-year prospective cohort study. Clin Oral Implant Res. 2005;16:326–334.
32. Kreissl ME, Gerds T, Muche R, Heydecke G, Strub JR. Technical complications of implant-supported fixed partial dentures in partially edentulous cases after an average observation period of 5 years. Clin Oral Implant Res. 2007;18:720–726.
33. Romeo E, Tomasi C, Finini I, Casentini P, Lops D. Implant-supported fixed cantilever prosthesis in partially edentulous jaws: a cohort prospective study. Clin Oral Implant Res. 2009;20:1278–1285.
34. Tawil G, Aboujaoude N, Younan R. Influence of prosthetic parameters on the survival and complication rates of short implants. Int J Oral Maxillofac Implants. 2006;21:275–282.

35. Gracis S, Michalakis K, Vigolo P, Vult von Steyern P, Zwahlen M, Sailer I. Internal vs. external connections for abutments/reconstructions: a systematic review. Clin Oral Implant Res. 2012;23(Suppl 6):202–216.
36. Sailer I, Muhlemann S, Zwahlen M, Hammerle CH, Schneider D. Cemented and screw-retained implant reconstructions: a systematic review of the survival and complication rates. Clin Oral Implant Res. 2012;23(Suppl 6):163–201.
37. Olsson M, Gunne J, Astrand P, Borg K. Bridges supported by free-standing implants versus bridges supported by tooth and implant. A five-year prospective study. Clin Oral Implant Res. 1995;6:114–121.
38. Gunne J, Astrand P, Lindh T, Borg K, Olsson M. Tooth-implant and implant supported fixed partial dentures: a 10-year report. Int J Prosthodont. 1999;12:216–221.
39. Block MS, Lirette D, Gardiner D, Li L, Finger IM, Hochstedler J *et al.* Prospective evaluation of implants connected to teeth. Int J Oral Maxillofac Implants. 2002;17:473–487.
40. Mau J, Behneke A, Behneke N, Fritzemeier CU, Gomez-Roman G, d'Hoedt B *et al.* Randomized multicenter comparison of two coatings of intramobile cylinder implants in 313 partially edentulous mandibles followed up for 5 years. Clin Oral Implants Res. 2002;13:477–487.
41. Hall JA, Payne AG, Purton DG, Torr B. A randomized controlled clinical trial of conventional and immediately loaded tapered implants with screw-retained crowns. Int J Prosthodont. 2006;19:17–19.
42. Crespi R, Capparé P, Gherlone E, Romanos GE. Immediate versus delayed loading of dental implants placed in fresh extraction sockets in the maxillary esthetic zone: a clinical comparative study. Int J Oral Maxillofac Implants. 2008;23:753–758.
43. Galli F, Capelli M, Zuffetti F, Testori T, Esposito M. Immediate non-occlusal vs. early loading of dental implants in partially edentulous patients: a multicentre randomized clinical trial. Peri-implant bone and soft-tissue levels. Clin Oral Implant Res. 2008;19:546–552.
44. Ganeles J, Zöllner A, Jackowski J, Ten Bruggenkate C, Beagle J, Guerra F. Immediate and early loading of Straumann implants with a chemically modified surface (SLActive) in the posterior mandible and maxilla: 1-Year results from a prospective multicenter study. Clin Oral Implant Res. 2008;19:1119–1128.
45. Güncü MB, Aslan Y, Tümer C, Güncü GN, Uysal S. Inpatient comparison of immediate and conventional loaded implants in mandibular molar sites within 12 months. Clin Oral Implant Res. 2008;19:335–341.
46. Schincaglia GP, Marzola R, Giovanni GF, Chiara CS, Scotti R. Replacement of mandibular molars with single-unit restorations supported by wide-body implants: immediate versus delayed loading. A randomized controlled study. Int J Oral Maxillofac Implants. 2008;23:474–480.
47. Degidi M, Nardi D, Piattelli A. Immediate versus one-stage restoration of small-diameter implants for a single missing maxillary lateral incisor: a 3-year randomized clinical trial. J Periodontol. 2009;80:1393–1398.
48. Prosper L, Crespi R, Valenti E, Capparé P, Gherlone E. Five-year follow-up of wide-diameter implants placed in fresh molar extraction sockets in the mandible: immediate versus delayed loading. Int J Oral Maxillofac Implants. 2010;25:607–612.
49. Koyano K, Tsukiyama Y, Kuwatsuru R. Rehabilitation of occlusion – science or art? J Oral Rehabil. 2012;39:513–521.
50. Wie H. Registration of localization, occlusion and occluding materials for failing screw joints in the Branemark implant system. Clin Oral Implant Res. 1995;6:47–53.
51. Carlsson GE. Dental occlusion: modern concepts and their application in implant prosthodontics. Odontology. 2009;97:8–17.

Correspondence: K. Koyano, Section of Implant and Rehabilitative Dentistry, Division of Oral Rehabilitation, Faculty of Dental Science, Kyushu University, 3-1-1 Maidashi, Higashi-Ku, Fukuoka 812-8582, Japan. E-mail: koyano@dent.kyushu-u.ac.jp