Splinting Osseointegrated Implants and Natural Teeth in Partially Edentulous Patients: A Systematic Review of the Literature

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Dental implants in partially edentulous patients are a predictable therapeutic option. In patients with reduced bone volume, tooth-to-implant connected prostheses have been described as a treatment option. In this systematic review, the incidence of biologic and technical complications and the long-term survival rates of tooth-implant supported fixed partial dentures (FPDs) are analyzed. In cases where a natural tooth is connected with an implant to support a FPD, a rigid connection should be preferred.

Key Words: systematic review, longitudinal studies, combined tooth-implant supported prosthesis, complications rates, survival rates, biologic complications

INTRODUCTION

Over the last decades, the use of osseointegrated dental implants in partially edentulous patients has become a commonly accepted therapeutic option to restore dentitions, both esthetically and functionally. In addition to a solely implant-supported fixed partial denture (FPD), tooth-to-implant connected prostheses have been proposed as a treatment alternative.

Originally, the Branemark protocol[1] for implant surgery recommended that dental implants should be freestanding from natural teeth due to the difference in biomechanics and anatomy. In fact, natural teeth have a substantially larger physiological mobility than implants, which are rigidly attached to bone. Natural teeth with a healthy periodontium demonstrate a mobility of about 50–200 μm whenever a force of 0.1 N is applied.[2] On the other hand, mobility of an osseointegrated dental implant is less than 10 μm upon application of similar forces.[3]

The threshold for tactile perception between natural teeth and implants as

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abutments for FPD is significantly different. In natural teeth that serve as abutments of FPDs, tactile perception was demonstrated to be significantly higher (8.8-fold) than that for osseointegrated implant abutments.[4] The threshold for tactile sensitivity as perceived with dental implants remained unchanged during a healing phase of 3 months.[5]

In clinical cases with reduced bone volume (especially in posterior edentulous areas) where only a single implant can be inserted, the connection of a natural tooth with an implant to support a FPD seems inevitable. Several studies have described clinical cases where FPDs are supported by a connection between implants and natural teeth.[6,7] These studies indicated the possibility of connecting implants to natural teeth in a FPD with a relatively good prognosis. However, these studies noticed the flexibility of the Branemark implant system as a reason for success.[8] On the other hand, studies have reported a pronounced marginal bone loss and even loss of osseointegration in FPDs combining implant and teeth, especially when these FPDs are close to natural teeth.[9]

Only a limited number of studies have evaluated the long-term prognosis of FPDs supported by teeth and implants.[10,11] The primary objective of this article is to systematically review the literature available regarding the incidence of biologic and technical complications as well as the long-term survival rates of tooth-implant supported FPDs over an observation period of more than 5 years.

Materials and Methods

A MEDLINE (PubMed) search was conducted to retrieve relevant articles published between January 1980 and May 2010. The search included English-language articles published in the dental literature. The key words used were: "dental implant complications," "dental implant failure," "tooth to implant connection," "tooth to implant supported," "dental implant intrusion," "rigid attachment," "nonrigid attachment," "partial edentulism," and combinations of these terms.

Furthermore, a manual search of all full-text articles and related reviews was applied to the following peer-reviewed journals for the years 1990–2010: *The Journal of Prosthetic Dentistry, The International Journal of Prosthodontics, Clinical Implant Dentistry and Related Research, The International Journal of Oral & Maxillofacial Implants, The International Journal of Periodontics & Restorative Dentistry, Clinical Oral Implants Research, Journal of Clinical Periodontology, Journal of Periodontology, Journal of Dental Research, and Journal of Periodontal Research*.

The inclusion criteria involved only prospective and retrospective clinical studies, controlled clinical studies and any kind of cohort study with a mean follow-up time of at least 5 years. Research studies based on questionnaires, patients' records, abstracts, and opinion articles were excluded from the review process.

Two independent reviewers (A.M. and K.K.) screened all titles and abstracts for possible inclusion in the review. Then, the full text of all studies was obtained and screened further by the 2 reviewers against the inclusion criteria. Data from multiple studies on the same patient cohort were declined.

Information extracted from included studies was independently related to survival rates of combined tooth-to-implant supported restorations and on biologic and technical complications by the 2 reviewers.

Peri-implantitis and intrusion of the tooth that was connected to the implant were considered biologic complications. Technical complications involved any kind of mechanical damage of the abutment teeth, the implant, the implant components, and the supported prosthetic suprastructure.

Statistical analysis

For the overall proportion of tooth and implant abutment loss, exact binomial

TABLE 1

Design and characteristics of reviewed studies included in the systematic review*

Study ID #	Authors/Year	Implant System	Study Design	Patient Number	Study Center	Patient Age Range, y	Out Rate, %
1	Akça and Cehreli[12]	Straumann	Prospective	29	University	31–73 (mean 48.3)	n.r.
2	Nickenig et al[13]	Branemark and Straumann	Retrospective	224	Specialist clinic and university	21.7–78 (mean 51.3)	n.r.
3	Nickenig et al[14]	Branemark and Straumann	Retrospective	83	Specialist clinic	22–61 (mean 45.4)	n.r.
4	Brägger et al[15]	Straumann	Prospective	21	University	19–78 (mean 49.3)	n.r.
5	Block et al[16]	Omniloc	Prospective	30	University	20–56	25
6	Mau et al[17]	IMZ	Prospective multicenter	258	University	20–71	18
7	Naert et al[18]	Branemark	Retrospective	123	University	20–79 (mean 51.8)	8
8	Kindberg et al[19]	Branemark	Retrospective	36	Specialist clinic	17–28 (mean 60.6)	3
9	Brägger et al[20]	Straumann	Prospective	15	University	23–83 (mean 55.7)	n.r.
10	Hosny et al[21]	Branemark	Prospective	18	University	37–65 (mean 49.5)	n.r.
11	Gunne et al[22]	Branemark	Prospective	20	University	n.r. (mean 58)	13
12	Fartash and Arvidson[23]	Bioceram	Prospective	14	University	20–73 (mean 51.2)	0
13	Olsson et al[24]	Branemark	Prospective	22	University	n.r. (mean 58)	4
14	Steflik et al[25]	Bioceram	Prospective	17	University	n.r.	6
15	Jemt et al[26]	Branemark	Retrospective	9	Specialist clinic	21–68 (mean 42.7)	0
16	Koth et al[27]	Bioceram	Prospective	18	University	n.r.	0
			Total patient #	937	Age/drop out range	17–83	0–25

*n.r. indicates not reported.

confidence intervals were calculated for each study. The summary estimate (a single ratio estimate for all studies included in the analysis) was calculated with inverse variance weighted meta-analysis by using the Freeman-Tukey arcsine transformation.

To calculate the summary survival estimate for FPDs and implants, the overall failure rates were first estimated, and by using the formula $S(T) = \exp(-T * FR)$ the T-years (5 or 10 years) survival was calculated, assuming constant failure rates (FR). Specifically, in each study failure rates were calculated by dividing the total number of FPDs or implant failures by the total exposure time in years. The overall failure rate (all studies) was estimated using random effects Poisson regression models, where the total number of failures was the outcome variable and the total exposure time of each study was used as an offset.

RESULTS

No randomized controlled clinical trials were found in the literature. From a total yield of 3290 titles and abstracts, only 16 studies concerning combined tooth-implant supported FPDs met the inclusion criteria (Table 1).[12–27] Five were retrospective cohort studies and 11 were prospective studies (Table 1). Thirteen different patient cohorts are reported in these studies with an observation period of more than 2 years (Table 2).

The following commercially available

TABLE 2

Absolute numerical values and characteristics of implants and FPDs, follow-up range and mean values of the studies included in the systematic review*

Study ID #	Authors/Year	Total No. of Implants	Total No. of FPDs	Cemented Prosthesis	Screw-Retained Prosthesis	Telescopic System	Follow-up Range, y
1	Akça and Cehreli[12]	64	49	49	0	n.r.	2–2.5 (mean follow-up was 2.2 mo)
2	Nickenig et al[13]	459	229	140	34	55	2–10 (mean follow-up 6.7 mo)
3	Nickenig et al[14]	142	84	29	41	14	2.2−8.3 (mean follow-up 4.73 mo)
4	Brägger et al[15]	22	22	10	12	n.r.	8–12 (mean follow-up 10 mo)
5	Block et al[16]	80	60	0	60	n.r.	5
6	Mau et al[17]	297	189	n.r	n.r.	n.r.	5
7	Naert et al[18]	339	140	0	140	n.r.	1.5–15 (mean follow-up 6.5 mo)
8	Kindberg et al[19]	115	41	0	41	n.r.	1–8.9 (mean follow-up 5 mo)
9	Brägger et al[20]	19	18	n.r.	n.r.	n.r.	5
10	Hosny et al[21]	31	18	0	18	n.r.	1.3–14 (mean follow-up 6.5 mo)
11	Gunne et al[22]	23	23	0	23	n.r.	10
12	Fartash and Arvidson[23]	27	22	n.r.	n.r.	n.r.	10
13	Olsson et al[24]	23	23	0	23	n.r.	5
14	Steflik et al[25]	28	15	15	0	n.r.	10
15	Jemt et al[26]	43	12	0	12	n.r.	6–19 n.r.
16	Koth et al[27]	28	15	15	0	n.r.	5
	Total implant/FPD, no.	1740	960				

*FPD indicates fixed partial denture; n.r., not reported.

implant systems were reported: ITI dental implant system (Straumann AG, Waldenburg, Switzerland), Branemark system (Nobel Biocare AB, Göteborg, Sweden), Bioceram sapphire implants (Kyocera America Inc, San Diego, Calif), IMZ system (Friedrichfeld, Mannheim, Germany), and the Omnilocs implant system (formerly Calcitek; now Sulzer Dental, Carlsbad, Calif).

Studies were conducted either in a university dental facility or in a private dental practice. One study was designed as a multicenter trial.[7] The average follow-up time was up to 10 years and in total, 1740 oral implants and 950 FPDs were examined (Table 2).

Implant failure and survival rates were estimated for all 16 studies (Table 3). Of the original 1740 implants that were placed, 117 were lost (Table 3); 25 were lost before functional loading and 68 were lost during function.

For the 5-year follow-up studies, the summary estimate 5-year survival rate was 90.96% (95% CI: 83.58%–95.12%) (Table 3), and the summary failure estimate was 1.89% (95% CI: 1.00%–3.59%) (Table 3).

For the 10-year follow-up studies, the summary estimate for implant survival was 82.19% (95% CI: 55.79%–93.59%) (Table 3), and the summary failure estimate was 1.97% (95% CI: 0.66%–5.84%) (Table 3). Implant loss prior to functional loading was detected in 1.6% of all implants placed, and implant loss during function was 7.4% of all functioning implants.

Tooth-to-implant supported FPD survival rates were also estimated for an observation period of 5 and 10 years. A FPD was defined as survived when it remained in situ for the 5- and 10-year

TABLE 3

Implant failure and estimated survival rates*

Study ID #	Authors/Year	Total No. of Implants	Mean Follow-up (Range), y	Total Exposure Time (Months)	No. of Implant Failures	Estimated Failure Rate (per 100 Years), %	Estimated 5-Year Survival Rate, %	Estimated 10-Year Survival Rate, %
5-Year follow-up								
1	Akça and Cehreli[12]	64	2.2 (2–2.5)	128	0	.00	100.00	
3	Nickenig et al[13]	142	4.73† (2.2–8.3)	n.a.	0	–	–	
5	Block et al[16]	80	5	357	1	.28	98.61	
6	Mau et al[17]	297	5	1112	51	4.59	79.51	
7	Naert et al[18]	339	6.5 (1.5–15)	2040	19	.93	95.45	
8	Kindberg et al[19]	115	5 (1–8.9)	431	9	2.09	90.09	
9	Brägger et al[20]	19	5	93	1	1.08	94.77	
10	Hosny et al[21]	31	6.5 (1.3–14)	195	1	.51	97.47	
13	Olsson et al[24]	23	5	100	2	2.00	90.48	
16	Koth et al[27]	28	5	108	6	5.56	75.75	
	Summary estimate (95% CI), %					(1.00–3.59)	90.96 (83.58–95.12)	
10-Year follow-up								
2	Nickenig et al[13]	459	6.7† (2.11–5.8)	n.a.	3	–		–
4	Brägger et al[20]	22	10 (8–12)	198	5	2.53		77.68
11	Gunne et al[22]	23	10	186	2	1.08		89.81
12	Fartash and Arvidson[23]	27	10	270	0	.00		100.00
14	Steflik et al[25]	28	10	207	9	4.35		64.74
15	Jemt et al[26]	43	n.r. (6–19)	n.a.	8	–		–
	Summary estimate (95% CI), %					1.97		82.15 (55.79–93.59)

*n.r. indicates not reported; n.a., not applicable.
†Median.

period of study (Table 4). Of 534 tooth-to-implant supported FPDs, 42 were lost during function. For the 5-year follow-up period, the summary estimate for the survival rate was 94.73% (95% CI: 89.27%–97.45%), and the summary estimate for failure was 1.08% (95% CI: 0.52%–2.27%) (Table 4). On the other hand, for the 10-year follow-up period, the summary estimate for survival was 77.77% (95% CI: 64.85%–86.42%), and the summary estimate for failure was 2.51% (95% CI: 1.46%–4.33%) (Table 4).

Data on tooth and implant abutment survival in combined tooth-implant FPDs were reported in 11 studies (Table 5). Loss of abutment teeth was primarily due to caries, fractures, endodontic complication, and periodontitis. After an observation period of 5 years, 2.76% of the abutment teeth and 2.53% of the functionally loaded implants were lost. The summary estimate for the survival rate for abutment teeth was 2.72% (95% CI: 1.62%–4.27%) (Table 5) and for implants 2.53% (95% CI: 1.56%–3.89%) (Table 5).

After a 10-year follow up period, 5.64% of the abutment teeth and 1.98% of the functionally loaded implants were lost. The summary estimate for the survival rate was 5.65% (95% CI: 3.78%–8.06%) for teeth and 1.98% (95% CI: 0.96%–3.62%) for implants (Table 5). The study-specific and meta-analytic estimated proportion (%) of tooth and implant loss is illustrated in Figures 1 and 2.

Information on biologic complications was provided in 5 studies.[14,15,20,21,27] A biologic complication is present when probing depth is more that 5 mm with a simultaneous bleeding on probing (peri-implantitis). Two studies reported biologic complications as rare events: less than 1% after 5 years under risk, in 1 study[14] and

TABLE 4

Combined tooth-implant supported FPD failure and estimated survival rates*

Study ID #	Authors/Year	Total No. of FPDs	Mean Follow-up (Range), y	Total Exposure Time (Months)	No. of FPD Failures	Estimated Failure Rate (per 100 Years), %	Estimated 5-Year Survival Rate, %	Estimated 10-Year Survival Rate, %
5-Year follow-up								
1	Akça and Cehreli[12]	34	2.2 (2–2.5)	68	0	0.00	100.00	
3	Nickenig et al[13]	84	4.73† (2.2—8.3)	n.a.	2	–	–	
5	Block et al[16]	n.a.	5	–	–	–	–	
6	Mau et al[17]	n.a.	5	–	–	–	–	
7	Naert et al[18]	n.a.	6.5 (1.5–15)	–	–	–	–	
8	Kindberg et al[19]	41	5 (1–8.9)	201	3	1.49	92.81	
9	Brägger et al[20]	18	5	88	1	1.14	94.48	
10	Hosny et al[21]	18	6.5 (1.3–14)	117	0	0.00	100.00	
13	Olsson et al[24]	23	5	100	2	2.00	90.48	
16	Koth et al[27]	15	5	73	1	1.37	93.38	
	Summary estimate (95% CI), %					1.08 (0.52–2.27)	94.73 (89.27–97.45)	
10-Year follow-up								
2	Nickenig et al[13]	229	6.7† (2.1–15.8)	n.a.	19	–		–
4	Brägger et al[20]	22	10 (8–12)	198	7	3.54		70.22
11	Gunne et al[22]	23	10	186	3	1.61		85.10
12	Fartash and Arvidson[23]	n.a.	10	–	–	–		–
14	Steflik et al[25]	15	10	133	3	2.26		79.81
15	Jemt et al[26]	12	n.r. (6–19)	n.a.	1	–		–
	Summary estimate (95% CI), %					2.51 (1.46–4.33)	77.77 (64.85–86.42)	

*FPDs indicates fixed partial dentures; n.r., not reported; and n.a., not applicable.
†Median.

less than 5% after 10 years in another study.[15] But in other studies, an increased rate of biologic complications was evident; 3 of 21 implants had radiographic evidence of infrabony pocket formation after an observation period of 5 years.[27] And similarly, 10% of patients or 9.6% of implants were affected after an observation period of 5 years,[20] and reporting on the same cohort after an observation period of 10 years, 13.6% of the implants were treated for peri-implantitis.[21] The estimated rate of biologic complications reported for the previous cohorts was 11.7% (95% CI: 9.7%–14.7%).

Technical complications of implants were categorized into abutment/occlusal screw loosening or abutment/occlusal screw fracture. Only 4 studies reported on implant abutment complications.[13–15,22] In 1 study, 3 screw or abutment fractures were detected and 9 of 276 screw-retained abutments were loosened.[13] In another study, screw loosening was documented in 7 of 72 screw-retained reconstructions with a recurrence rate of 8% after 3 years.[14] In 2 studies, 26.4% (95% CI: 20.3%–33.9%) of abutment screws demonstrated loosening and 0.7% (95% CI: 0.5%–0.9%) of FPDs had abutment or abutment screw fractures.[15,22]

In cases of cemented FPDs, the loss of cementation could be considered a technical complication. Only 1 study[13] reported clearly on that; 6 of 67 cemented connections between implants and FPDs revealed loss of cementation.

Loss of retention of FPDs was reported in 4 studies without mentioning clearly whether FPDs were cemented or screw retained. The rate of retention loss varied from 6.2% (95% CI: 3.7%–10.4%) to 26.4% (95% CI: 20.3%–33.9%) in a study period of 5 to 10 years.[15,18,21,23] Another technical

TABLE 5

Loss of tooth and implant abutments*

Study ID #	Authors/Year	Tooth-to-Implant FPD	Tooth Abutment	Tooth Abutment Loss	Implant Abutment	Implant Abutment Loss
5-Year follow-up						
1	Akça and Cehreli[12]	34	–	0	64	0
3	Nickenig et al[13]	84	132	3	142	0
5	Block et al[16]	60	60	5	60	1
7	Naert et al[18]	140	313	5	339	10
8	Kindberg et al[19]	41	85	5	112	6
9	Brägger et al[20]	18	18	0	19	1
10	Hosny et al[21]	18	30	0	30	0
13	Olsson et al[24]	23	23	0	23	2
	Summary estimate			2.72		2.53
	proportion 95% CI), %			(1.62–4.27)		(1.56–3.89)
			(661)	(18)	(789)	(20)
10-Year follow-up						
2	Nickenig et al[13]	229	449	23	459	3
4	Brägger et al[20]	22	24	4	22	5
11	Gunne et al[22]	23	23	1	23	2
	Summary estimate			5.65		1.98
	proportion (95% CI), %			(3.78–8.06)		(0.96–3.62)
			(496)	(28)	(504)	(10)
	Overall estimate			3.98		2.32
	proportion (95% CI), %			(2.93–5.27)		(1.57–3.30)

*FPDs indicates fixed partial dentures.

complication reported in 2 studies was veneer fracture; veneer fracture rate was reported as being 4 of 41 FPDs or 9.8% at 5 years[19] and 2 of 22 FPDs or 9.1% after 10 years.[15]

Finally, intrusion of natural teeth was reported in 6 studies (Table 6).[13,16,18–21] The estimated rate of teeth intrusion ranged from 0.00% to 3.36% with a summary estimate of 1.07% (95% CI: 0.40%–2.87%) (Table 6). Finally, the 5 year estimated complication rate varied from 0.00 to 15.47% (summary estimate was 5.21% with 95% CI:1.98%–13.35%) (Table 6).

DISCUSSION

The prominent aim of the systematic review was to address the survival and complication rates of FPDs supported by a combination of teeth and implants. Longitudinal cohort studies with a mean follow-up time of at least 5 years regarding survival rates and biologic and technical complications of tooth-implant supported FPDs were included. Sixteen studies met the inclusion criteria and were included in this study. In general, longitudinal cohort studies that did not provide clear information on study duration, type of suprastructures, and survival or event rates were not included in this systematic review.

The estimated failure of implants (per 100 years) was 1.89% after 5 years and 1.97% after 10 years. Implant loss prior to functional loading was detected in 1.6% of all implants placed. Implant loss during function was 7.4% of all implants functioning. Previous systematic reviews confirm these results.[11,27,28]

The estimated failure rate (per 100 years) of the combined tooth-implant supported FPDs was 1.08% after 5 years and 2.51% after 10 years. Previous systematic reviews demonstrated similar results for the 5-year period; however, at 10 years, the estimated failure rate was remarkably higher for the combined tooth-implant supported FPDs when compared to solely implant-supported FPDs.[28] This is a signif-

Table 6

Intrusion of tooth abutments*

Study ID #	Authors/Year	Tooth Abutment	Total Exposure Time (Months)	Intrusions	Estimated Intrusion Rate, %	Estimated Complication Rate (5 y), %
2	Nickenig et al[13]	449	n.a.	16	–	–
5	Block et al[16]	60	357	12	3.36	15.47
7	Naert et al[18]	313	1884	11	.58	2.88
8	Kindberg et al[19]	85	327	3	.92	4.48
9	Brägger et al[20]	18	88	0	.00	.00
10	Hosny et al[21]	30	195	0	.00	.00
	Summary estimate (95% CI), %				1.07 (0.40–2.87)	5.21 (1.98–13.35)

*n.a. indicates not applicable.

icant experimental observation about the 10-year prognosis of FPDs supported by a combination of tooth and implants. However, further well-organized controlled clinical studies of similar nature must become available in order to make definite recommendations on the long-term survival and failure rates of combined tooth-implant supported FPDs.

After a follow-up period of 5 years, the summary estimate proportion for abutment loss was 2.72% for teeth and 2.53% for implants. After a 10-year observation period, the summary estimate for abutment loss was 5.65% for teeth and 1.98% for implants. A statistically significant difference was observed between loss of abutment teeth and loss of implants during the observation periods. Hence, we can speculate that the reason for lower survival rates of combined tooth-implant supported FPDs is probably the observed higher failure rates of the abutment teeth.

Biologic complications were also reported in 5 studies.[14,15,20,21,27] Peri-implantitis was evident in 1 study[20] where 10% of patients or 9.6% of implants were affected after an observation period of 5 years. Reporting on the same cohort after an observation period of 10 years, 13.6% of implants were treated for peri-implantitis.[15] The estimated rate of biologic complications reported for the previous cohorts was 11.7% (95% CI: 9.7%–14.7%). Previous systematic reviews on FPDs supported by a combination of teeth and implants provided similar estimated cumulative rates of biologic complications.[11]

Splinting implants to natural tooth may also result in bone loss due to the uneven distribution of forces. Biomechanical studies based on 2- and 3-dimensional finite element analysis revealed that in 2 dimensions, when a 50-kg load per piece was applied for 10 seconds on both an implant and a natural tooth, forces were concentrated on the implant collar and tooth apex. In 3 dimensions, when forces of 50 kg were applied for 5 milliseconds, they were distributed over the whole implant surface, although more were distributed to the implant collar and to the cervical area of the tooth's alveolar bone. It was concluded then that a prolonged static load endangers peri-implant bone more than alveolar bone. It appears that periodontal ligament plays a key role in stress distribution in tooth-to-implant connection.[29]

The incidence of technical complications was also evaluated. Implant abutment complications were divided into complications that included either screw loosening or screw fracture. In 1 study, 3 screw or abutment fractures were detected and 9 of 276 screw-retained abutments were loosened.[13] In another study, no screw or abutment fracture was evident, but screw loosening was documented in 7 of 72 screw-retained FPDs with a recur-

rence rate of 8% after 3 years.[14] In 2 studies, 26.4% (95% CI: 20.3%–33.9%) of the abutment screws demonstrated loosening.[15,22] In 2 other studies, 0.7% (95% CI: 0.5%–0.9%) of FPDs had abutment or abutment screw fractures. These were the rarest complications observed.

Loss of cementation could be considered a technical complication for FPDs. Only 1 study[13] reported clearly on that; 6 of 67 cemented connections between implants and FPDs revealed loss of cementation. In addition, loss of retention of FPDs was reported in 4 studies without mentioning clearly whether FPDs were cemented or screw retained.[15,18,21,23] The rate of loss of retention varied from 6.2% (95% CI: 3.7%–10.4%) to 26.4% (95% CI: 20.3%–33.9%) in a study period of 5 to 10 years.[15,18,21,23] However, it must be clarified that these rates are based only on a small amount of FPDs. The most common technical complication reported in 2 studies was veneer fracture. The first study reported veneer fractures in 4 of 41 FPDs or 9.8%.[19] Another study reported on fractures of veneers after 10 years in 2 of 22 FPDs or 9.1%.[15] In this way, it can be stated that posttreatment complications may result in an increased rate of unscheduled patient visits.

A potential problem of combining

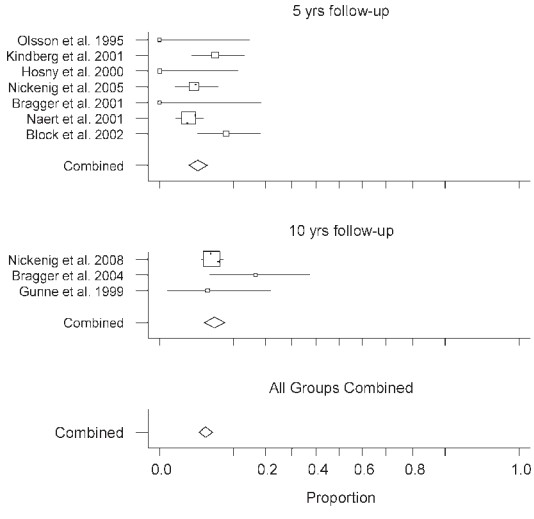

Figure 1. Study-specific and meta-analytic estimated proportion (%) of abutment-teeth loss.

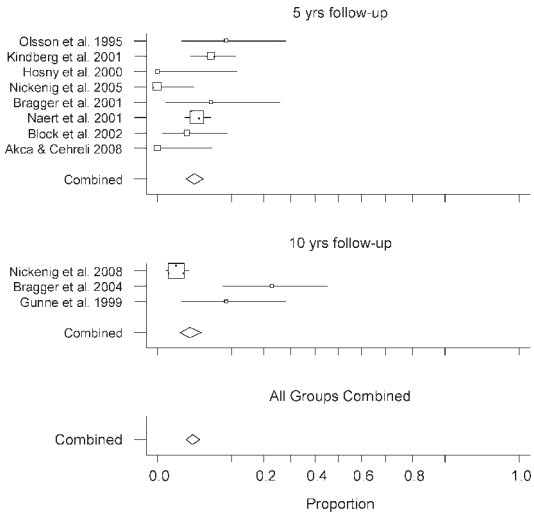

Figure 2. Study-specific and meta-analytic estimated proportion (%) of abutment-implant loss.

teeth and implants to support FPDs was tooth intrusion phenomenon. Six studies included in the systematic review provided information on intrusion.[13,16,18–21] After a 5-year follow-up period, the estimated rate of intrusion ranged from 0.00% to 3.36%. The summary estimate of intrusion rate in combined FPDs was 1.07% (95% CI: 0.40%–2.87%). The effect on abutment teeth and implants rigidly or nonrigidly connected in a combined tooth-implant supported FPD was examined in 1 study[16]; intrusion was evident in 66% for nonrigid connections, and 44% for rigid connections. However, 25% of the nonrigid connections had greater than 0.5 mm intrusion of abutments compared to 12.5% of the FPDs with rigid connections. In another study,[19] intrusion was evident in 3 of 36 patients with nonrigid connections. Finally, in a previous study that examined 3096 sites with implant-tooth connections in mixed FPDs for an observation period ranging between 3 and 14 years,[19] intrusion was detected in only 9 cases. All 9 cases were associated with fractures or loosening of the rigid connection. In this way, it becomes clear that intrusion of abutment teeth in combined tooth-implant supported FPDs is mainly detected for nonrigid connections.

Conclusions

Combined tooth-implant supported FPDs have an estimated 5-year survival rate of 94.73% and a 10-year rate of 77.77%. Simultaneously, the summary estimate proportion for abutment tooth loss is 2.72% (95% CI: 1.62%–4.47%) for the 5-year follow-up period and 5.65% (95% CI: 3.78%–8.06%) for the 10-year period. Meanwhile, the summary estimate proportion for abutment implant loss was 2.53% (95% CI: 1.56%–3.89%) for the 5-year period and 1.98% (95% CI: 0.96%–3.62%) for the 10-year period. Hence, we can speculate that the increased failure rates of abutment teeth might be responsible for the relatively low survival rates of FPDs during the 10-year follow-up period.

Taking into consideration the aforementioned research results and systematic review data on FPDs that are solely implant-supported from previous studies,[30] it can be suggested that treatment plans should involve solely implant-supported FPDs, if possible. However, in clinical cases where the connection of a natural tooth with an implant to support a FPD seems inevitable (ie, reduced bone volume, especially in posterior edentulous areas where only a single implant can be inserted), a rigid connection should be established by the 2 different abutments. Finally, more well-designed longitudinal studies must be performed to assess the clinical efficacy of combined tooth-implant supported FPDs.

Abbreviations

FPD: fixed partial denture
FR: failure rates

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The *Journal of Oral Implantology* Editorial staff has discovered that the article published as "in-press" electronically by *JOI* titled, "Immediate Placement and Provisionalization of Implant-Supported, Single-Tooth Restorations: A Retrospective Study," by Edgard El Chaar, DDS, MS, and Raphael Bettach (doi: 10.1563/AAID-JOI-D-11-00071; PMID: 21905899) has previously been published in the *International Journal of Periodontics and Restorative Dentistry* under the title, "Immediate Placement and Provisionalization of Implant-Supported, Single-Tooth Restorations: A Retrospective Study," by Edgard S. El-Chaar, DDS, MS (2011;31:409–419; PMID: 21837307). As this constitutes duplicate publication, which is against *JOI* editorial policy, the article has been retracted by the American Academy of Implant Dentistry, publisher of *Journal of Oral Implantology*.