Influence of Platform Switching, Abutment Design and Connection Protocols on the Stability of Peri-Implant Tissues. A Systematic Review

Keywords

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Authors

Ghada Soliman * §
(DClinDent (Pros), MSc (Pros), BDS (Hons), MRACDS (Pros), FRACDS)

Massimiliano Guazzato §
(PhD, DClinDent (Pros), BDS, FRACDS, MRACDS (Pros), DT)

Iven Klineberg ‡^
(AM, RFD AM, MDS, BSc, FDSRCS, FRACDS, MRACDS, FICD)

Michael C. Chang * §
(DClinDent (Pros), MRACDS (Pros), BDent, BSc)

Ayman Ellakwa Δ
(BDS, MSc (Prosthodontics), PhD, FDSRCS, FRACDS, FICD)

Address for Correspondence

Ghada Soliman *

Email: gsol5395@uni.sydney.edu.au

* *Oral Restorative Sciences Department, Westmead Centre for Oral Health, Darcey Road, Westmead, 2145, Australia*

§ *Lecturer, Sydney Dental School, The University of Sydney, NSW 2006 Australia*

‡ *Level 3, Westmead Centre of Oral Health Darcy Road, C24, Westmead Hospital, The University of Sydney, NSW 2006 Australia*

^ *Emeritus Professor, Sydney Dental School, The University of Sydney*

Δ *Head of Prosthodontics Department, Sydney Dental School, The University of Sydney, NSW 2006 Australia*

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ABSTRACT

Purpose: To appraise the effect of abutment factors namely platform switching, design and connection protocols on the stability of peri-implant tissues. Materials and Methods: An electronic and hand search were conducted. Randomized control trials and controlled prospective studies of at least one-year follow-up, published in the last 12 years, were included. Results: Initial electronic database search generated 3054 studies, while individual journal and hand searching resulted in 232 articles. Sixty-three publications were selected for full text analysis based on inclusion and exclusion criteria. Nineteen articles investigated platform switching. Fourteen studies reported positive influence of platform switching while five studies did not find a significant difference in bone loss compared to platform matched abutments. Two articles reported on concave abutments and found no advantage over conventional abutments. Seven studies investigated "one-abutment-one-time protocol", two found comparable results to multiple abutment disconnections while five studies suggested better soft and hard tissue maintenance. The risk of bias was unclear or high in most studies. Conclusion: Platform switched abutments may reduce crestal bone loss during the first year. There is insufficient evidence to suggest better clinical outcomes of concave abutment. There is insufficient evidence to indicate the superiority of 'one abutment-one-time protocol'.

INTRODUCTION

The advent of osseointegrated implants has revolutionized dental treatment in both partially and completely edentulous patients. High implant success and survival are well documented in the literature.[1-3] In spite of a great difference existing between implant success and survival, these two terms tend to be loosely used resulting in confusion. A surviving implant might not be necessarily successful due to lack of function or failed aesthetics. Maintenance of peri-implant bone and soft tissue are considered to be the main factors required for implant success.

Progressive loss of peri-implant supporting structures indicates a disease process termed peri-implantitis. Many risk factors have been identified such as smoking, history of periodontitis, poor oral hygiene, diabetes and lack of keratinized mucosa.[4-8] In addition, the implant abutment can also play a major role in reducing the risk of peri-implantitis by supporting peri-implant soft tissues, creating an epithelial seal and resisting apical migration around implants.[9]

Many clinical studies have shown that varying abutment size,[10,11] material,[12,13] design,[14] roughness and surface topography,[15,16] size of implant-abutment microgap,[17,18] and number of abutment reconnections[19-21] can result in varying degrees of peri-implant bone and soft tissue response, which can influence initiation of peri-implantitis in the long-term. However, robust clinical evidence is lacking for the general practitioner to select the most appropriate abutment in clinical situations.[22] The scientific evidence in the literature is unclear regarding the clinical outcomes of platform switching and there is a lack of definitive documentation on the impact of repeated implant-abutment disconnection and reconnection.[23] In addition, abutment design recommendations are sometimes based on histological outcomes from animal studies rather than clinical outcomes from well conducted human studies.[14,24] Hence, this systematic review was undertaken as a trial to find the best possible evidence on selecting abutments that will maintain peri-implant tissues.

The formulated PICO question was: What are the effects of platform switching, novel abutment design and one-abutment one-time connection protocol as compared to platform matched abutments, standard abutments and multiple abutment disconnections on the preservation of hard and soft tissues in patients receiving dental implants? The null hypothesis stated was that different abutments will result in similar peri-implant crestal bone and soft tissue changes.

MATERIALS AND METHODS

A detailed approach was undertaken based on the preferred reporting items for systematic reviews and meta-analyses (*PRISMA/Table 1*) guidelines.[25]

TEST GROUP

The studies were included if they reported on the following interventions: use of platform switched abutment (PSA), novel abutment design involving geometry or surface microstructure and definitive abutment at time of surgery. Control group: a prerequisite for study inclusion was the existence of a control intervention in the form of use of a platform matched abutment (PMA), standard abutment design, and provisional or healing abutment.

INCLUSION CRITERIA

Randomized control trials and prospective clinical trials with control groups published in peer reviewed journals since 2007. The follow-up period was at least 1-year from abutment connection. The study population included patients who received single or multiple dental implants in healed sites or immediately after tooth extraction. There was no restriction on patient age, type of implant loading and prosthesis design. The included studies did not exclude smoking and a previous history of periodontal disease.

EXCLUSION CRITERIA

In vitro, animal and retrospective studies, studies conducted on less than 10 patients in either test or control groups, and implants placed for overdenture prosthesis.

SEARCH STRATEGY

Identification

The search strategy incorporated both an electronic and hand search. The following electronic databases were utilised: Ovid/MEDLINE, The Cochrane Libraries, Embase, PREMEDLINE, PubMed, and Google Scholar. "Index term search" was first run using the following terms "dental abutment", "dental implant-abutment design", "dental implantation, endosseous", "dental implants". This step was followed by text word search using the following terms: "peri-implant tissue" OR "periimplant tissue" OR "tissue biotype" OR "tissue architecture" OR "marginal bone loss" OR "bone loss" OR "soft tissue recession" OR "bone resorption" OR "bone remodelling" OR "peri-implantitis" OR "periimplantitis" OR "mucositis". "implant abutment material" OR "implant abutment design" OR "scalloped implant" OR "platform-switched implant" OR "gingival converged implant" OR "concave implant abutment" OR "titanium zirconium alloy" OR "commercially pure titanium" OR "nonporous titanium dioxide" OR "micro-gap" OR "microgap" OR "abutment" OR "titanium nitrite" OR "gold alloy" OR "connection" OR "reconnection" OR "re-connection" OR "disconnection" OR "misfit". Hand search was also undertaken utilizing the reference list of the included papers and relevant systematic reviews. The results were limited to human studies with no language restrictions.

Screening and selecting

A 3-step search strategy was adopted in this review. Article titles were scanned by two independent reviewers. Further filtration was carried out through the abstract and full text reviewing. Any disagreements between reviewers were resolved through discussion or inclusion of a third reviewer. In cases where the same authors had several publications for the same study, the most recent publication only was included in the analysis. This would allow reviewing the study with the most complete dataset.

Quality assessment and risk of bias

An appraisal of the methodological characteristics of the primary studies was undertaken to identify risk of bias. Quality assessment was done on both study and outcome levels to evaluate reliability and validity of data for each individual study. Elected articles for full text review were assessed using "Grading of Recommendations Assessment, Development, and Evaluation" (GRADE) tool. The GRADE tool is designed to determine quality of evidence and identify limitations in study design and execution. It categorises the quality of evidence into high, moderate, low, or very low and the risk of bias is classified into high, uncertain, or low (*Table 2 & Figure 1*).

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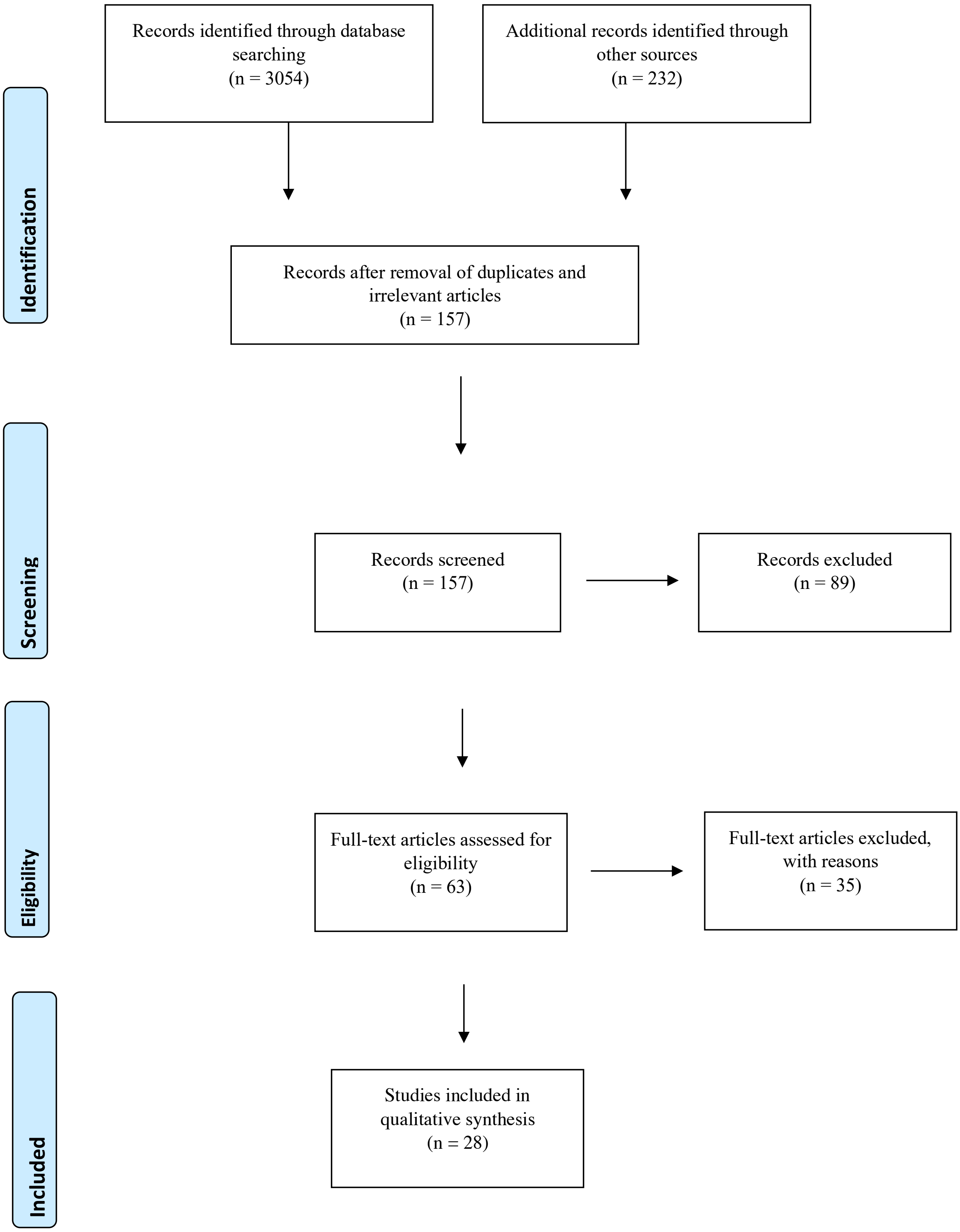

Table 1. PRISMA Flow Diagram used in the current study.[24]

RESULTS

The initial electronic database search generated 3054 studies, while individual journal and hand searching resulted in 232 articles. Removal of duplicates and irrelevant articles followed by title review resulted in 157 studies available for abstract screening. Finally, 63 publications were selected for full text analysis based on previously stated inclusion and exclusion criteria. The most common reasons for exclusion were differences in study design compared to that included in the research protocol, insufficient number of patients or follow-up period, irrelevant outcome data, and duplicate studies by the same authors.

Table 2. Quality assessment and risk of bias: no study was completely free of bias

		A	B	C	D	E	F
Platform switching	Cappiello *et al* 2008	−	−	−	+	+	?
	Crespi *et al* 2009	−	−	+	?	?	?
	Prosper *et al* 2009	+	?	+	−	?	+
	Trammel *et al* 2009	−	−	−	?	+	+
	Vigolo and Givani 2009	−	−	+	+	+	?
	Canullo *et al* 2010	+	−	−	−	−	?
	Fickl *et al* 2010	−	−	−	+	?	?
	Veis *et al* 2010	−	−	−	?	?	+
	Pieri *et al* 2011	+	+	?	?	?	+
	Canullo *et al* 2012	+	+	−	+	+	?
	Enkling *et al* 2013	+	−	−	+	+	+
	Guerra *et al* 2014	+	+	−	+	−	+
	Meloni *et al* 2014	+	+	?	+	+	+
	Pozzi *et al* 2014	+	−	+	+	+	+
	Telleman *et al* 2014	?	−	?	+	+	+
	Canullo *et al* 2016	+	+	+	−	−	?
	Telleman *et al* 2017	+	−	−	−	?	+
	Saito *et al* 2018	−	−	−	?	?	?
	Cooper *et al* 2019	+	?	?	−	?	?
Abutment connection	Canullo *et al* 2010	+	−	+	+	+	?
	Degidi *et al* 2011	−	−	−	?	+	?
	Grandi *et al* 2012	+	−	−	+	+	?
	Degidi *et al* 2014	+	?	+	−	−	+
	Grandi *et al* 2014	+	−	+	+	+	+
	Bressan *et al* 2017	?	?	?	?	?	+
	Çömlekoglu *et al* 2018	?	?	+	+	+	+
Abutment Geometry	Weinländer *et al* 2011	+	−	?	+	+	+
	Patil *et al* 2014	?	−	+	?	?	+

A: Allocation concealment (selection bias)
B: Blinding of participants and personnel (performance bias)
C: Blinding of outcome assessment (detection bias)
D: Intention to treat analysis (loss of follow-up)
E: Incomplete outcome data (attrition bias)
F: Selective reporting (reporting bias)

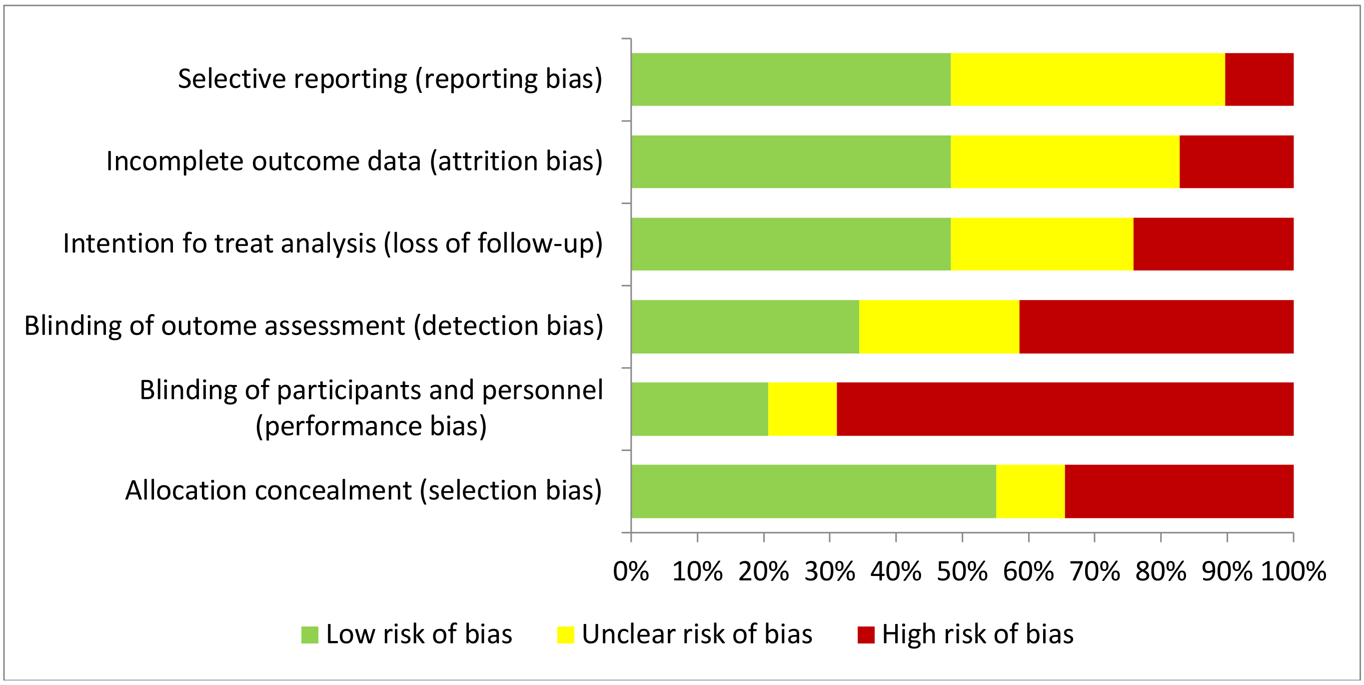

Figure 1. Statistical representation of the risk of bias

Thirty-three articles satisfied the 3-step screening process and were categorised with respect to their context to platform switching,[19] abutment geometry,[2] one-abutment-one-time protocol.[7] Details of selected study design and population are listed in *(Table 3)* and include year of publication, patient number and age, study setting, implant number and follow-up period. The comparison of the outcome data is listed in (*Table 4*) and provides information on implant success rate, vertical and horizontal bone level changes, peri-implant mucosal changes, and aesthetics.

The selected studies in platform switching presented great diversity regarding implant placement and loading protocols. In nine studies,[26-34] implants were placed in healed sites and were submerged for the conventional healing period. In two studies,[35,36] implants were placed immediately after tooth extraction and were immediately restored but without occlusal contacts. In two studies,[37,38] immediate provisional restorations were placed following implant placement in healed sites. In two studies,[39,40] implants were immediately placed after tooth extraction and loaded. In four studies,[41-44] healing abutments were connected immediately after implant placement in healed sites.

The implant-abutment mismatch was developed in two ways: either by varying the implant diameter through use of regular and wide platform implants,[28,30,34,41-43] or by varying the abutment diameter.[26,27,29,31,33,35-37,39,44] Only one randomized control trial[32] utilized 2 different implant and abutment diameters and two studies[38,40] did not report on the amount of mismatch or implant and abutment diameters used.

There was a paucity in high level research evidence that evaluated novel abutment designs regarding both geometry and surface characteristics. Only 2 randomized control trials[45,46] fulfilled the inclusion criteria. Both studies were conducted for one year and examined a concave abutment design compared with a conventional straight[46] or convex[45] design.

Seven studies[21,47-52] reported on the 'one-abutment one-time' concept. All were randomized control trials except Degidi *et al* (2011)[48] which was a prospective study incorporating a control group. Implants were placed in the maxilla and mandible, and in the anterior and posterior regions. All implants were immediately restored using definitive or provisional abutments. Provisional abutments were removed at least 3-4 times compared to non-removal of definitive abutments.

There was also a great variability in the type of implant restorations investigated in the studies. However, all studies used the same implant prosthetics for both test and control abutments. Twelve publications[26,31-33,35-38,40,41,43,53] studied single implant restorations with platform matched and platform switched designs. Implant bridges were placed in four studies[28,34,42,54] while two studies[39,44] investigated the outcome of the platform switched protocol in both single and splinted implant restorations. In two studies[29,30] the type of implant restoration was not mentioned.

Both studies, selected for abutment design examined outcomes in single implant crowns. Weinlander *et al* (2011)[45] connected the abutments in provisional restorations immediately after implant placement in posterior regions of the maxilla and mandible. Patil *et al* (2014)[46] submerged the implants in the maxillary and mandibular anterior regions.

The outcome of one-abutment one-time protocol was investigated in single implant crowns[21,47,50,52] and in implant bridges.[48,49] Only one study examined both single and splinted implant restorations.[51]

The information on the type of implant restoration in selected studies is listed in Table 5.

Table 3. Details of selected studies design and population

Authors	Year	Study design	Patient number	Drop-outs	Age range	Study setting/ location	Region	Implant number	Follow-up
Platform switching									
Cappiello *et al*	2008	P	45	1	NI	NI	NI	131	16 Ms
Crespi *et al*	2009	P	45	NI	25-67	Uni	Anterior (max, mand)	64	2 Ys
Prosper *et al*	2009	RCT	68	8 (2.9%)	25-70	12 Private centres	Posterior (max, mand)	408 (60 each gp)	2 Ys
Trammel *et al*	2009	RCT	10	NI	≥19	NI	Mandible	25	2 Ys, 9 Ms
Vigolo and Givani	2009	P	144	None	25-55	Private	Post Max & Mand	182 (85 PM, 97 PS)	5 Ys
Canullo *et al*	2010	RCT	31	5	36-78	NI	Post Max	80	33 Ms
Fickl *et al*	2010	P	36	None	17-69	Uni	NI	89 (75PS, 14PM)	13 Ms
Veis *et al*	2010	P	NI	NI	NI	Uni	NI	282 (CG 193, TG 89)	2 Ys
Pieri *et al*	2011	RCT	40	2 (1TG, 1 CG)	≥18	Uni	Max premolar	40	12 Ms
Canullo *et al*	2012	RCT	40	None	>18, average 58.2	Private clinics	Post Max (1st premolar-2nd molar)	80	18 Ms
Enkling *et al*	2013	RCT	25	None	51±10.5	NI	Posterior mandible	50	3 Ys
Guerra *et al*	2014	RCT	68 (35 PS, 33PM)	NI	>18	Multi-centre	Posterior mandible	146 (74 PS, 72 PM)	1 Y
Meloni *et al*	2014	RCT	18	None	≥18	Uni + Private	Molar region	36 (18 PS, 18 PM)	1 Y
Pozzi *et al*	2014	RCT	34	None	39-59	Uni	Posterior mandible	88 (44 PS, 44 PM)	3 Ys, 2 Ms
Telleman *et al*	2014	RCT	17	None	≥18	Uni	Posterior maxilla & mandible	62 (31 PS, 31 PM)	16 Ms
Canullo *et al*	2016	RCT	22	1 PS 2 PM	32-76	2 Private centres	Anterior maxilla	22 (11 PS, 11 PM)	10 Ys

Table 3 continued overleaf.....

Table 3 continued

Telleman *et al*	2017	RCT	80	5	23-75	Uni	Posterior maxilla & mandible	75 (37 PS, 38 PM)	5 Ys
Saito *et al*	2018	P	56	NI	22-75	NI	Anterior maxilla	56 (28 PS, 28 PM)	1 Y
Cooper *et al*	2019	RCT	111	15	18-81	4 study centres	Anterior max & premolar	45 CC, 34 PM, 32 PS	3 Ys
Abutment dis/reconnection									
Canullo *et al*	2010	RCT	25	None	>18	Multi-centre Private	Maxillary premolars	25 (10 PA, 15 DA)	3 Ys
Digidi *et al*	2011	P	24	3	≥18 µ 49.3	NI	Posterior mandible	48 (24 PA, 24 DA)	3 Ys
Grandi *et al*	2012	RCT	28	None	39-64	Private centres (3)	NI	48 (24 PA, 24 DA)	1 Y
Degidi *et al*	2014	RCT	68	6	µ 40.1 DA 37.7 PA	Private office	Anterior maxilla	68 (35 PA, 33 DA)	2 Ys
Grandi *et al*	2014	RCT	25	None	39-74	Private centres (2)	Anterior maxilla & mandible	25 (13 PA, 12 DA)	1 Y
Bressan *et al*	2017	RCT	80	8	>18	4 Private Centres	Ant/Post Max/Mand	80 (40 HA, 40 DA)	3 Yrs
Çömlekoğlu *et al*	2018	RCT	16	None	µ 36.1	Uni	Anterior maxilla	16 HA, 16 DA	1 Y
Abutment design									
Weinländer *et al*	2011	RCT	10	None	µ 35±13	Uni	Posterior maxilla & mandible	20 (10 SA, 10 CA)	1 Y
Patil *et al*	2014	RCT	26	NI	17-56	Private centre	Anterior maxilla & mandible	52 (26 SA, 26 CA)	1 Y

P: prospective, RCT: randomized control trial, NI: not indicated, Ms: months, Ys: years, PM: platform matched, PS: platform switched, PA: provisional abutment, DA: definitive abutment, HA: healing abutment, SA: standard abutment, CA: concave abutment, Ti: titanium abutment, Zr: zirconia abutment, Au: gold abutment, TiN: titanium nitride abutment

Table 4. Study outcomes of included papers

Authors	Year	Implant failure	Estimated success rate	Vertical marginal bone level changes (mm)	Horizontal marginal bone level changes (mm)	Peri-implant mucosal changes	Aesthetics	Radiographic evaluation	P Value/CI
Platform switched									
Cappiello *et al* (P)	2008	1 test	96.9%	SSD PM -1.67 ±0.37 PS -0.95 ±0.32	NI	NI	NI	PA + custom holder	.001
Crespi *et al* (P)	2009	None	100%	NSSD PM -0.78 ±0.45 PS -0.73 ±0.52	NI	NI	NI	PA + custom holder	>.05
Prosper *et al* (RCT)	2009	8	97.1%	Border-line SSD Platform enlarged: PM & PS 0 Control: PM -0.27 5±0.467 PS -0.045 ±0.227	NI	NI	NI	PA + film holder	<.001
Trammel *et al* (RCT)	2009	None	100%	SSD PM -1.19 ±0.58 PS -0.99 ±0.53	NI	Surrogate biologic width: NSSD PM -1.53 ±0.78 PS -1.57 ±0.72	NI	PA + custom holder	≤.0001
Vigolo and Givani (P)	2009	None	100%	SSD PM -1.1 ±0.3 PS -0.6 ±0.2	NI	NI	NI	PA + custom holder	<.05
Canullo *et al* (RCT)	2010	11	NI	SSD: PM -1.48 PS1 -0.99 PS2 -0.83 PS3 -0.64	NI	NI	NI	PA + custom holder	<.005
Fickl *et al* (P)	2010	None	100%	SSD PM: -1 ±0.22 PS: -0.39 ±0.07		NI		Standard PA	<.01
Veis *et al* (P)	2010	NI	NI	Supracrestal: NSSD PM -0.6 ±0.67PS -0.69 ±0.47 Crestal: NSSD PM -1.23 ±0.96 PS -1.13 ±0.42 Subcrestal: SSD PM -0.81 ±0.79 PS -0.39 ±0.52	NI	NI	NI	PA + film holder or OPG (cropped)	<.001
Pieri *et al* (RCT)	2011	1 test	CG 100% TG 94.7%	SSD PM -0.49 ±0.25 PS -0.19 ±0.17	NI	NSSD in PH, mid-buccal mucosa, mucosal thickness	NI	PA + custom holder	Bone <.05 Soft tissue <.001

Table 4 continued overleaf.....

Table 4 continued

Canullo *et al* (RCT)	2012	None	100%	SSD PM: -1.6 ±0.3 mm PS: -0.5 ±0.1 mm	NI	Soft tissue height: PM: -2.4 mm PS: -0.6 mm	NI	PA + custom holder	≤.05
Enkling *et al* (RCT)	2013	None	100%	NSSSD PM -0.74 ±0.57 PS -0.69 ±0.43	NSSD PM -0.46 ±0.37 PS -0.35 ±0.50	NI	NI	OPG	95%
Guerra *et al* (RCT)	2014	2 PS	NSSD 97.3%PS 100%PM	SSD PM -0.69 ±0.58 PS -0.40 ±0.46	NI	NI	NI	PA + custom holder	0.004
Meloni *et al* (RCT)	2014	None	100%	NSSD PM -0.93 ±0.26 PS -0.84 ±0.23	NI	NI	NI	PA + film holder	95% >.05
Pozzi *et al* (RCT)	2014	None	100%	SSD PM -1.24 ±0.47 PS -0.67 ±0.39	SSD PM -0.60 ±0.20 PS -0.20 ±0.21	NI	NI	PA + custom holder	0.000 95%
Telleman *et al* (RCT)	2014	2 PS 2 PM	93.6% PS 93.6% PM	SSD PM -0.85 ±0.65 PS -0.53 ±0.54	NI	NI	NI	PA + film holder	.003
Canullo *et al* (RCT)	2016	None	100%	SSD PM -0.8 ±0.40 PS -0.18 ±0.14		SSD BMH PM -0.59 ±0.80 PS 0.23 ±0.51 PH PM -1.12 ±0.53 PS 0.21 ±0.33	NI	PA + custom holder	95%
Telleman *et al*	2017	3 PS 4 PM	94.5% PS 93.1% PM	NSSD PM -0.413 ±0.472 PS -0.382 ±0.612	NI	NSSD	NI	PA + film holder	0.290
Saito *et al*	2018	None	100%	NI	NI	SSD Mid-facial thickness PM 2.17 ±0.04 PS 3.55 ±0.14	NI	None	<.05
Cooper *et al*	2019	14	PM 83.7% PS 86.4% CC 100%	SSD: CC vs PM, PS PM -1.02 PS -1.04 CC -0.12	NI	SSD BPPD>4mm PM 18% PS 9% CC 7% LPPD>4mm PM 24% PS 12.5% CC 2%	PES NSSD	PA	.014

Table 4 continued overleaf.....

Table 4 continued

Abutment dis/reconnection									
Canullo *et al* (RCT)	2010	None	100%	SSD PA -0.55 ±0.09 DA -0.34 ± 0.07	NI	MPPD PA 2.8 ±0.21 DA 2.75 ±0.07	NI	PA + custom holder	.000001 95%
Digidi *et al* (P)	2011	None	100%	NSSD PA -0.541 DA -0.608	SSD PA +0.104 DA +0.225	NI	NI	PA + custom holder	<.05
Grandi *et al* (RCT)	2012	None	100%	SSD PA -0.435 DA -0.094	NI	NI	NI	PA + custom holder	<.001
Degidi *et al* (RCT)	2014	None	100%	NSSD PA -0.18 DA -0.17	SSD PA -0.03 DA -0.18	Recession PA -0.59 ±0.21 DA -0.32 ±0.13	NI	CBCT	.03 M .04 D
Grandi *et al* (RCT)	2014	None	100%	SSD PA -0.58 ±0.11 DA -0.11 ±0.06	NI	NI	NI	PA + holder	<.0001
Bressan *et al*	2017	1	98.8%	SSD HA -0.50 ±0.93 DA -0.07 ±0.18	NI	B recession NSSD	PES NSSD	PA + holder	0.007
Çömlekoğlu *et al* (RCT)	2018	None	100%	SSD HA -0.26 ±0.10; -0.18 ±0.11 DA -0.17 ±0.11; -0.12 ±0.09	NI	PI, GI NSSD	PES NSSD	CBCT + bite splint	<0.05
Abutment geometry									
Weinländer *et al* (RCT)	2011	None	100%	NSSD SA -0.11 ±0.77 CA -0.34 ±0.53	NI	BMH: SSD SA 2.1 ±0.94 CA 1.3 ±0.42	PES: SSD SA 8 ±1.89 CA 10.5 ±1.72	PA + holder	>.05 <.05
Patil *et al* (RCT)	2014	NI	NI	NSSD SA -0.12 ±0.27 CA -0.00 ±0.37	NI	PPD: NSSD SA 3.37 ±0.36 CA 3.41 ±0.3	PES NSSD SA 9.7 ±2.3 CA 10 ±2.3	PA + custom holder	.25 .41

SSD: statistically significant difference, NSSD: no statistically significant difference, M: mesial, D: distal, PM: platform matched, PS: platform switched, PA: periapical radiograph, OPG: orthopantomography, CC: conical connection, PH: papilla height, MBH: buccal mucosal height, PI: plaque index, GI: gingival index, MPPD: mean peri-implant probing depth, PIS: papilla index score, Ti: titanium abutment, Zr: zirconia abutment, Au: gold abutment, TiN: titanium nitride abutment, MBL: mesial bone level, DBL: distal bone level, PA: provisional abutment, DA: definitive abutment, SA: standard abutment, CA: concave abutment, PES: pink aesthetic score, NI: not indicated
- Indicates tissue loss + Indicates tissue gain

Table 5. Type of implant restoration for platform switched protocol, abutment dis/reconnection, and abutment geometry

Single implants	Implant bridges	Not mentioned
Platform switching		
Cappiello *et al* 2008	Prosper *et al* 2009	Fickl *et al* 2010
Crespi *et al* 2009	Trammel *et al* 2009	Veis *et al* 2010
Vigolo and Givani 2009	Crespi *et al* 2009	
Pieri *et al* 2011	Canullo *et al* 2010	
Enkling *et al* 2013	Canullo *et al* 2012	
Guerra *et al* 2014	Telleman *et al* 2014	
Meloni *et al* 2014		
Pozzi *et al* 2014		
Telleman *et al* 2014		
Canullo *et al* 2016		
Telleman *et al* 2017		
Saito *et al* 2018		
Cooper *et al* 2019		
Abutment dis/reconnection		
Canullo *et al* 2010	Digidi *et al* 2011	
Degidi *et al* 2014	Grandi *et al* 2012	
Grandi *et al* 2014	Bressan *et al* 2017	
Bressan *et al* 2017		
Çömlekoğlu *et al* 2018		
Abutment Geometry		
Weinländer *et al* 2011		
Patil *et al* 2014		

DISCUSSION

This systematic review showed that different abutment designs and connection protocols can influence peri-implant soft tissue and marginal bone response and the stated hypothesis was rejected. The effect of these factors was also evaluated on implant success and dimensional changes in hard and soft tissues. Meta-analysis was not performed due to the heterogeneity of the selected studies. The study design among selected articles varied significantly regarding implant placement and loading protocols, type of implant restorations, methods and standardization techniques for hard and soft tissue evaluation. In addition, absence of evidence that all implants in the selected studies were placed at a standardized distance from the alveolar crest added to the heterogeneity of our review.[55] The inclusion of non-randomized controlled prospective studies may have further introduced bias.[56]

In spite of the differences in study design between selected publications, all studies used same type of implant restoration for both test and control groups. Hence, we believe that the type of implant prosthetics did not influence the hard and soft tissue outcomes.

Most of the studies in this review were randomized control trials (RCTs) which are often considered to be the "gold standard" of clinical trials. Despite being the least biased study design, true RCTs are extremely difficult to employ in the dental field because of reasons of feasibility and ethics considerations.[57] Prospective studies with control groups were also included in this review. They represent high quality evidence compared to observational retrospective studies.[58]

The concept of platform switching was introduced by Lazzara and Porter in 2006.[59] It was suggested that horizontal inward repositioning of the implant-abutment interface resulted in inward shifting of the inflammatory infiltrate at implant-abutment junction. Consequently, platform switching modality was established to preserve and limit peri-implant bone loss. It was also reported that platform switching had the mechanical advantage of reducing the shear stress at the bone-implant interface by shifting the high stress area toward the centre of the implant reducing the strain energy in the cortical bone surface.[60]

This review found significantly less initial alveolar bone height loss with platform switched compared to platform matched abutments. This difference tended to disappear after 1 year of loading.[26,30,33,39] These findings agree with the results of other systematic reviews.[55,56,61] Atieh *et al* (2010)[56] and Junior *et al* (2016)[55] stated that there was a significant reduction in crestal bone loss in platform switched as compared to platform matched implants. The mean difference of bone loss between groups was 0.68 mm[56] and 0.41 mm[55] respectively which represents a statistical significance but not necessarily a clinical significance. In addition, an inherent limitation was the marked heterogeneity between included studies. Implants were not placed at a standardized distance from the alveolar crest.[55,56] Some studies showed that implants placed under the alveolar crest showed more significant peri-implant bone loss compared to implants installed at bone level irrespective of abutment type.[18,62,63]

The majority of studies included in this review had short observational periods ranging from 1 to 3 years. The longest study reporting beneficial effects of platform switching was conducted by Canullo *et al* (2017)[36] for 10 years. However, due to the small sample size and strict inclusion criteria, the results obtained by Canullo *et al* are likely to have limited application to the wider population.

The platform switched protocol was primarily introduced to maintain marginal bone levels which is an important factor for maintaining soft tissue aesthetics around anterior implants. Collectively, across all of the studies reviewed, only 192 out of 2,042 implants were placed in the anterior maxilla utilizing the platform switched concept. This limited number raises questions concerning the statistical power of the data to draw definitive conclusions regarding influence of platform switched protocol in preserving peri-implant crestal bone.

The data indicated the difference in bone loss ranged between 0.2-0.7 mm which might not be of clinical significance and may represent a lack of consistency in accuracy of measurements of bone levels. It is well known that radiographic measurements of marginal bone levels are associated with inherent inaccuracies which makes the accuracy of the measurement differences questionable.[64] Another important factor which may potentially attenuate the validity of such small differences in bone measurements is the ambiguity of the radiographic techniques used. There was no standardisation of the measuring techniques, as orthopantomograms or periapical radiography with and without a film holder were used. Some studies reported using custom film holders but did not mention the method of fabrication.[26-28,35,39,41-43] Additionally, it was demonstrated that the accuracy of periapical radiographs suffers greatly when using conventional paralleling devices, which consequently reduces accuracy of image interpretation during crestal bone level assessments.[65]

There is no evidence that platform switching plays an important role in soft tissue height preservation. Three articles reported favourable results including two studies presented by the same group.[27,36] They had a limited sample size[36] and one study used different implant/abutment connections between groups.[27] In contrast Hsu *et al* (2017) reported a protective effect of platform switched abutments on peri-implant soft tissues which indirectly maintained the peri-implant crestal bone levels.[66] However, the authors stated that this conclusion should be interpreted with caution due to the random reporting on the soft tissue outcomes and the high experimental heterogeneity of their included studies. Furthermore, the marginal bone preservation tended to be pronounced at sites with thicker tissue biotypes.[66] Hence, the initial peri-implant tissue thickness rather than the abutment design, might play an important role in preserving hard and soft tissues.[67]

Experimental modifications of abutments was attempted to create a thicker connective tissue attachment with improved resistance to epithelial migration.[68,69] For example, some abutments were designed to incorporate microchannels on the abutment surface. It was reported that this topography intensified fibroblastic activity, produced dense connective tissue fibres, prevented soft tissue recession and hence crestal bone loss.[14,24,70,71] None of these studies were included in the review as many were histological analyses[68,72] or the study design did not meet the inclusion criteria.[73,74]

Abutment geometry design was also considered in this review and only two studies[45,46] were included and reported on the concave abutment design. There is no evidence to suggest a superior outcome of this design for hard tissues, soft tissues and aesthetics. In addition, concave abutments do not appear to provide any advantage over customised abutments. The customisation can enhance abutment aesthetics by creating multiple degrees of curvatures to support specific transgingival morphology[46].

The repeated dis/reconnection of abutments was found to influence the peri-implant hard tissue response.[21,47-52] The difference in bone loss ranged between 0.2 and 0.4 mm, thus casting doubt on the clinical relevance of the difference between the two protocols.[51] Despite being statistically significant, such small differences could be entirely attributed to examiner variability rather than a true finding between the different treatment modalities. It was shown that measurement discrepancies can reach up to 0.4-0.5 mm between different observers.[75] The method of standardisation of serial radiographs is another important factor. Poor standardisation techniques may be misleading causing over or underestimation of the treatment outcome. Inaccurate angulation can cause superimposition of bone leading to significant variations in crestal bone levels and densities.[65] There is high possibility that the results of these studies were also biased due to limitations in study design especially in the numbers of recruited participants which reduced the statistical power of most of the selected studies. In regards to soft tissue preservation, the evidence is insufficient as only one study reported preservation of 0.3 mm of buccal mucosa in the definitive abutment group and this difference would probably be within the measurement error and not clinically detectable.[21]

A limitation to this study was restricting the search to articles published since year 2007. This was done to assess the quality of evidence for new abutment designs and techniques which were only introduced in the market in the last twelve years. Conventional products that have been available for more than twelve years have long track records and are already supported by evidence.

CONCLUSION:

Within the limitations of this systematic literature review, the following conclusions can be made:

1. Platform switched abutments may reduce crestal bone loss during the first year. This effect tends to disappear with time.
2. There is insufficient evidence to suggest better clinical outcomes of concave abutment.
3. There is insufficient evidence to indicate the superiority of 'one-abutment one-time protocol' especially when the drawbacks of this technique are considered.

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