Clinical Outcomes of Implant Abutments in the Anterior Region: A Systematic Review

AVINASH S. BIDRA, BDS, MS*, **PATCHANEE RUNGRUANGANUNT,** DDS, MSD†

ABSTRACT

Statement of Problem: The clinical outcomes of anterior implant abutments are not well reported.
Purpose of the Study: To systematically review the existing literature to identify survival, mechanical, biological, and esthetic outcomes of anterior implant abutments.
Material and Methods: An electronic search was performed using PubMed/MEDLINE with specific search terms and predetermined criteria. After application of inclusion and exclusion criteria, the final list of articles was reviewed in-depth to meet the objectives of this review.
Results: Systematic application of inclusion and exclusion criteria resulted in identification of 27 studies that described outcomes of anterior implant abutments. Because of substantial heterogeneity of data, true survival, or cumulative survival of abutments could not be calculated. However, the mean failure of abutments was 1.15%, attributable to fractures restricted to ceramic abutments. Mechanical complications included abutment screw loosening, primarily restricted to external hex implants. Biological complications included fistulas and mucosal recession. Esthetic outcomes showed lesser gingival discoloration for zirconia abutments compared with metal abutments.
Conclusions: Minimal anterior abutment fractures have been reported and are restricted to ceramic abutments. Studies using spectrophotometry showed lesser gingival discoloration with zirconia abutments, but there is no evidence for difference in patient's esthetic satisfaction between ceramic and metal abutments.

CLINICAL SIGNIFICANCE

For the anterior region, selection of an implant with internal connection and a customized metal abutment (titanium or cast metal) can have the least mechanical complications. Limited existing clinical data indicate reduced peri-implant mucosal discoloration from zirconia abutments, which may be preferable over metal abutments, in patients with thinner mucosal tissues or patients with high or gummy smiles.

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INTRODUCTION

Current paradigms for treatment success in implant dentistry are based not only on true clinical outcomes such as implant survival, restoration survival, and patient satisfaction but also on surrogate clinical outcomes such as dentogingival esthetics, rate of mechanical complications, bone levels, and health of surrounding soft tissues. This is especially important for implant therapy in maxillary and mandibular anterior regions, where esthetics play a predominant role in treatment success. A variety of implants, abutments, and restorations differing in design and biomaterials have been introduced to achieve optimal mechanical, biological, and esthetic treatment outcomes.[1–27] The choice of an implant abutment in the anterior region is

*Assistant Professor and Assistant Program Director, Post-Graduate Prosthodontics, Department of Reconstructive Sciences, University of Connecticut Health Center, Farmington, CT, USA
†Associate Professor, Department of Reconstructive Sciences, University of Connecticut Health Center, Farmington, CT, USA

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primarily governed by: (1) patient's smile line (low, medium, high, or gummy smile), (2) nature of peri-implant mucosa (thick or thin), (3) angulation of the implant, (4) choice of crown material, (5) availability of restorative space, (6) type of restoration (screw- or cement-retained), (7) clinician's preference, and (8) treatment expenses. Different types of implant abutments have been described in the literature for use in the anterior region. They can be categorized based on method of connection to restoration, material, method of fabrication, and color (Table 1). Different characteristics of the abutment add to unique advantages and disadvantages.

Use of implants for single tooth restorations was first reported in 1986 by Jemt[28] and is rapidly emerging as the standard of care for partially edentulous patients. Historically, the prosthetic components such as abutment and retaining screw were directly derived from those being used to rehabilitate edentulous

TABLE 1. Categorization of different implant abutment designs

	Category	Options
1.	Method of connection to restoration	One-piece screw-retained abutment-crown complex Two-piece design with screw-retained crown over the abutment Two-piece design with cemented crown over the abutment
2.	Material	Titanium Cast metal (noble, high noble, or base metal alloy) Cast metal with porcelain fused at the base Alumina Complete zirconia Zirconia with a titanium base (zirconia-titanium hybrid abutment)
3.	Method of fabrication	Prefabricated (unmodified or modified) Customized cast abutment Customized copy-milled abutment Customized CAD-CAM abutment
4.	Color	Gold Silver (metallic finish) Pure white Customized white Customized pink/gingival shade at the cervical region

CAD-CAM = computer-aided design–computer-aided manufacturing.

patients. These were prefabricated machined components made of titanium and veneered primarily with acrylic resin resulting in a one-piece abutment-crown restoration.[27,28] In order to improve esthetics, this approach was later replaced by a two-piece restoration with a prefabricated titanium abutment supporting a cemented metal-ceramic crown.[28] This was followed by the introduction of the University of California Los Angeles (UCLA) abutment in 1988, which for the first time allowed customized cast metal component to be directly screwed into the dental implant.[29] This abutment continues to be popular, for screw- and cement-retained restorations. With evolution in esthetic implant dentistry, it was recognized that the metal abutments lead to a blue-grayish discoloration of the peri-implant soft tissue at the gingival margins that was considered objectionable by some clinicians for treatment success.

A solution to this problem was the introduction of a densely sintered alumina ceramic abutment in 1993 by Prestipino and Ingber.[30–32] The alumina ceramic abutment was an important breakthrough and was used in multiple clinical studies and was further improvised by using computer-aided design–computer-aided manufacturing (CAD-CAM) technology for fabrication.[23] Then, in 2004, Glauser and colleagues first described the densely sintered yttrium-stabilized zirconia as an alternative ceramic abutment.[22] They used a manually guided copy-milling technique to produce their abutment as a copy of a customized resin pattern. This was eventually followed by CAD-CAM technology for producing zirconia abutments. Since then, significant advancements in biological understanding has resulted in improved treatment protocols such as palatal placement of implants, surgical augmentation of thin soft tissues, and soft tissue development with interim restorations and platform switching, all of which now enable replacement of a missing anterior tooth to ideal esthetics and function.

Previous systematic reviews incorporating implant abutments have all combined treatment outcomes for anterior and posterior abutments.[33–35] Additionally, some systematic reviews have combined laboratory and

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clinical results to arrive to their conclusions. It is well known that biting/occlusal forces have different vectors and are significantly higher in the posterior regions than anterior regions because of the class III lever system in the human mandible.[36,37] When compared with the incisor region, occlusal forces are almost two times higher in the premolar region and three times higher in the molar region. Therefore, the clinical outcomes between anterior and posterior abutments may be significantly different. Additionally, esthetic parameters governing the selection of an anterior abutment may not necessarily apply to posterior regions. It is important that studies evaluating outcomes of prosthetic components delineate anterior and posterior regions, as their complications and survival outcomes may be significantly different. Therefore, the purpose of this study is to evaluate clinical outcomes including survival outcomes, mechanical outcomes, and biological and esthetic outcomes of implant abutments used exclusively in the maxillary and mandibular anterior regions.

MATERIAL AND METHODS

An electronic search of the English language literature between the periods of January 1970 and August 2012 was performed by using PubMed/MEDLINE with predetermined inclusion criteria. Key terms included in the search were: zirconia abutments, zirconium abutments, alumina abutments, gold abutments, ceramic abutments, porcelain abutments, esthetic abutments, CAD-CAM abutments, metal-free abutments, titanium abutments, and custom abutments. The inclusion criteria were: (1) English language article in a peer-reviewed journal, (2) any clinical study on humans involving any of the search terms listed, and (3) articles describing clinical studies on partially edentulous humans involving implant abutments in the maxillary and mandibular canine to canine region. The exclusion criteria were: (1) articles that did not pertain to abutments described in the inclusion criteria, (2) articles that described implants with a one-piece design (without a separate abutment), (3) articles that described the use of abutments solely for purposes of interim/provisional/transitional treatment, (4) review/technique articles without associated clinical trial and data, (5) case reports/series/studies with less than four abutments, (6) patients or data being repeated in other included articles, and (7) articles that did not provide the required data or did not allow extraction of the required data on anterior implant abutments.

The electronic search was conducted in three stages in a hierarchical order. At stage 1, a list of titles was obtained from the electronic databases, and each examiner independently analyzed pertinent titles based on the predetermined inclusion criteria. The examiners then debated the exclusion of these titles, and any disagreement was resolved by discussion. In case of any doubt, the title of the article was appropriately included for consideration in the next stage. At stage 2, both examiners independently screened the abstracts of all selected titles. Abstracts to be included for further scrutiny were again independently selected by the two authors. Any discrepancies between the authors were discussed until a consensus was reached. When in doubt, an abstract was incorporated for the next stage of full-text analysis of articles. At stage 3, both examiners carefully studied the full text of all included articles. A manual search complemented this stage by inclusion of additional full-text articles from citations that were reviewed in stage 3. Thereafter, exclusion criteria were applied, and the final list of articles was reviewed in-depth to meet the objectives of this systematic review. In this systematic review, survival was defined as presence of an implant abutment in function after placement. Failure was defined as absence or complete loss of the abutment requiring replacement by a new abutment. Complication was defined as introduction of an unplanned and unwanted event during treatment, which did not require replacement of the entire abutment, implant, or crown.

RESULTS

The search from the electronic database resulted in a total of 2,205 titles, out of which abstracts of only 64 titles were applicable to the study. Application of the predetermined exclusion criteria led to a total of 31 articles for full-text analysis. An in-depth manual search

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of citations from these 31 articles led to addition of 25 more articles resulting in a total of 57 full-text articles that were studied in detail. Further application of exclusion criteria resulted in elimination of 30 full-text articles[38–67] (Table 2). This lead to a total of 27 studies from which qualitative and quantitative data were extracted for analysis (Tables 3 and 4). Of the 27 studies, 4 were randomized clinical trials, 14 were prospective studies, 8 were retrospective studies, and 1 was a cross-sectional study. Majority of studies (20/27) were published during the recent 5-year period.

All 27 studies reported use of abutments in the anterior maxilla, with 12 of them also reporting use of abutments in the anterior mandible as well. The number of implant abutments reported in the anterior mandible was very low in all 12 studies. Almost all studies reported use of abutments to support single crown restorations, and only one study reported use of abutments to support fixed partial dentures.[5] Majority of studies (17/27) reported exclusively on internal connection between the abutment and the implant, nine studies reported exclusive use of external hex implants, and one study incorporated both types of implants. Majority of studies (22/27) reported use of cement-retained restorations making them appear as the popular choice for anterior implant restorations. The one-piece screw-retained restoration was reported in eight studies, and three studies reported on two-piece screw-retained restorations.

For abutment material, 16 studies reported use of titanium abutments, 4 studies on cast metal alloy abutments, 4 studies on alumina abutments, 13 studies on complete zirconia abutments, and 2 studies on zirconia abutments with a titanium base. For method of abutment fabrication, 16 studies reported on prefabricated abutments (zirconia and titanium), 4 studies on UCLA-type customized abutments, 8 studies on CAD-CAM customized abutments (zirconia and titanium), and 4 studies reported on special methods for customization including copy-milled technique. Different types of restorative materials were used for crown fabrication over the abutments ranging from (1) metal-ceramic cemented crowns, (2) all-ceramic cemented crowns (zirconia alumina and lithium disilicate), (3) porcelain veneered directly to cast metal abutment, titanium abutment, or ceramic abutment, and (4) acrylic resin veneered directly to cast metal or titanium abutment.

Only 11/27 studies reported exclusively on abutments in the anterior region. Consequently, the authors extracted data from the remaining 16 studies to compute a total of 951 anterior abutments from all 27 studies combined (Table 5). Because of substantial heterogeneity of data reporting, unclear data on follow-up (range 0.08–13 years), and lack of life table survival analysis, calculation of true survival or cumulative survival rate of the abutments was impossible. Additionally, two studies were descriptive in nature that compared esthetic outcomes and did not report any survival data. An unrefined mean survival estimate calculated for a total of 11 reported fractures resulted in a mean failure of 1.15%. All 11 fractures were reported for ceramic abutments with 8 fractures on alumina abutments and the remaining 3 fractures involving zirconia abutments. No abutment fractures were reported on titanium or cast metal abutments. Studies reporting mechanical outcomes listed abutment screw loosening as the primary complication, but the majority of these studies used external hex implants, for which abutment loosening is a well-recognized complication. Abutment screw fracture was reported in only one study,[27] making it appear to be a rare complication for anterior abutments. Complications for crowns over the abutments were reported in 14 studies, with most common complications being minor fracture/chipping of porcelain, prosthetic screw loosening, and loss of crown retention.

For biological outcomes, occurrence of fistulas was reported as the most common complication, both in screw-retained restorations (4/6) and cement-retained restorations (2/6). Another biological complication reported in six studies[9,15,17,23,24,27] was peri-implant mucosal recession. This complication was predominantly reported in studies using prefabricated abutments (titanium). All other biological surrogate treatment outcomes such as plaque index, marginal bone loss, and tissue health were unremarkable across

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TABLE 2. Summary of 30 excluded articles at full-text stage and reason for exclusion (30 total)

No.	Authors	Year of publication	Criteria for exclusion
1.	Wolleb *et al.*[38]	2012	Did not allow data extraction
2.	Brown and Payne[39]	2011	Did not allow data extraction
3.	Sailer *et al.*[40]	2009	Repeated data from another included article
4.	Jung *et al.*[41]	2008	Did not allow data extraction
5.	Bae *et al.*[43]	2008	Number of anterior abutments was less than 4.
6.	Kreissl *et al.*[42]	2007	Did not pertain to anterior abutments and did not allow data extraction
7.	Bischof *et al.*[44]	2006	Did not pertain to anterior abutments
8.	De Boever *et al.*[45]	2006	Did not allow data extraction
9.	Vigolo *et al.*[46]	2006	Did not pertain to anterior abutments
10.	Brägger *et al.*[47]	2005	Did not pertain to anterior abutments
11.	Romeo *et al.*[48]	2004	Did not allow data extraction
12.	Preiskel and Tsolka[49]	2004	Did not allow data extraction
13.	Andersson *et al.*[50]	2003	Did not allow data extraction
14.	Romeo *et al.*[51]	2003	Did not pertain to anterior abutments and did not allow data extraction
15.	Jemt *et al.*[52]	2003	Did not pertain to anterior abutments
16.	Krennmair *et al.*[53]	2002	Did not allow data extraction
17.	Behneke *et al.*[54]	2000	Did not allow data extraction
18.	Bianco *et al.*[55]	2000	Did not allow data extraction
19.	Eger *et al.*[56]	2000	Did not allow data extraction
20.	Sethi *et al.*[57]	2000	Did not allow data extraction
21.	Andersson *et al.*[58]	1999	Did not allow data extraction
22.	Wannfors and Smedberg[59]	1999	Did not allow data extraction
23.	Wyatt and Zarb[60]	1998	Did not allow data extraction
24.	Behr *et al.*[61]	1998	Did not allow data extraction
25.	Scheller *et al.*[62]	1998	Did not allow data extraction
26.	Andersson *et al.*[63]	1998	Did not allow data extraction
27.	Kastenbaum *et al.*[64]	1998	Did not allow data extraction
28.	Chapman and Grippo[65]	1996	Did not allow data extraction
29.	Henry *et al.*[66]	1996	Did not allow data extraction
30.	Lewis *et al.*[67]	1992	Did not allow data extraction

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TABLE 3. Summary of 27 included studies with qualitative data

Study name	Nature of the study	Setting	Abutment location	Type of implant restoration (single crown or FPD)	Type of connection of abutment to implant	Abutment manufacturer information
Camargos *et al.*[1]	Retrospective	Independent clinic	Maxilla and mandible	Single crown	External	Neodent
Cabello *et al.*[2]	Prospective	Private practice	Maxilla	Single crown	Internal	Straumann
Hosseini *et al.*[3]	Prospective	University	Maxilla	Single crown	Internal	Astra Tech
Canullo and Götz[4]	Prospective	Not reported	Maxilla	Single crown	Internal	Sweden & Martina
Kim *et al.*[5]	Prospective	University	Maxilla and mandible	Single crown and fixed partial dentures	External	Zir-Ace, Acucera, Pocheon, Koria
Furze *et al.*[6]	Prospective	Private practice	Maxilla	Single crown	Internal	Straumann
Gallucci *et al.*[7]	RCT	University	Maxilla	Single crown	Internal	Synocta 1.5 screw-retained abutment, Straumann
Happe *et al.*[8]	Retrospective	Private practice	Maxilla	Single crown	Internal	Cercon, Dentsply, Friadent
Cosyn *et al.*[9]	Prospective	University	Maxilla	Single crown	Internal	Esthetic abutment, Nobel Biocare
Ekfeldt *et al.*[10]	Retrospective	Private practice	Maxilla and mandible	Single crown	Internal and external	Procera, Nobel Biocare
van Brakel *et al.*[11]	Cross-sectional	University	Maxilla	Single crown	Internal	Astra
Bressan *et al.*[12]	Prospective	Multicenter study	Maxilla	Single crown	Internal	Astra
Redemagni *et al.*[13]	Retrospective	Private practice	Maxilla and mandible	Single crown	Internal	Not reported
Zembic *et al.*[14]	RCT	University	Maxilla and mandible	Single crown	External	Procera, Nobel Biocare
Jemt[15]	Retrospective	University	Maxilla	Single crown	External	TiAdapt and CeraOne, Nobel Biocare
Lee and Hasegawa[16]	Prospective	Not reported	Maxilla	Single crown	Internal	Zimmer Contour all-ceramic abutment, Zimmer
Chen *et al.*[18]	RCT	Not reported	Maxilla and mandible	Single crown	Internal and external	CerAdapt and zirconia abutments, Nobel Biocare
Cooper *et al.*[17]	Prospective	University	Maxilla	Single crown	Internal	Astra abutment ST titanium
Rompen *et al.*[19]	Prospective	University and private practice	Maxilla and mandible	Single crown	Internal	Experimental abutments and Procera, Nobel Biocare
Canullo[20]	Prospective	Private practice	Maxilla and mandible	Single crown	Internal	ProUnic abutment, impladent with Zirkonzahn
Zarone *et al.*[21]	Retrospective	University	Maxilla	Single crown	Internal	Procera Alumina and stock titanium abutments, Nobel Biocare

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TABLE 3. Continued

Study name	Nature of the study	Setting	Abutment location	Type of implant restoration (single crown or FPD)	Type of connection of abutment to implant	Abutment manufacturer information
Glauser *et al.*[22]	Prospective	University	Maxilla and mandible	Single crown	External	Wohlwend
Henriksson and Jemt[23]	Prospective	Independent clinic	Maxilla	Single crown	External	Procera, Nobel Biocare
Andersson *et al.*[24]	RCT	Multicenter study	Maxilla and mandible	Single crown	External	CerAdapt and CeraOne, Branemaek System, Nobel Biocare
Levine *et al.*[26]	Retrospective	Multicenter study	Maxilla and mandible	Single crown	Internal	Octa-abutment and conical-abutment, Straumann
Jemt[25]	Retrospective	Independent center	Maxilla and mandible	Single crown	External	Experimental adjustable titanium abutments, Nobel Biocare
Avivi-Arber and Zarb[27]	Prospective	University	Maxilla and mandible	Single crown	External	Prefabricated standard abutments and CeraOne abutments, Nobel Biocare

FPD = Fixed partial denture; RCT = randomized, controlled trial.

all studies. However, two studies examining an experimental concave-shaped abutment showed soft tissue stability, minimal soft tissue recession, and even a gain in soft tissue height.[13,19] For esthetic outcomes, change in color of peri-implant soft tissues because of the abutment was the commonly studied outcome. In general, studies using spectrophotometric analysis showed lesser peri-implant mucosal discoloration for zirconia abutments compared with metal abutments; studies using subjective-/objective-scoring criteria showed no difference in patient's esthetic satisfaction between the two kinds of abutments.

DISCUSSION

Survival Outcomes

Analyzing abutment survival outcomes was one of the primary objectives of this systematic review. However, multiple challenges in extraction of survival data from the included studies were: (1) majority of studies reported a broad follow-up period (range 0.08–13 years), (2) most studies did not report how many anterior abutments were followed during a specific time interval and did not clarify when the abutment failures occurred, (3) most studies (19/27) described follow-up periods of less than 5 years, and (4) few studies allowed generation of a life table survival analysis, impeding calculation of interval, or cumulative survival rates. Lack of similar outcome criteria and time periods made it difficult to draw conclusions on survival of anterior implant abutments. Furthermore, two studies were descriptive in nature that compared esthetic outcomes and did not report any survival data. Therefore, only a gross estimate of mean failures could be calculated for the 11 reported failures, which was 1.15%.

Out of 11 fractures, 4 alumina abutments were reported to have fractured at the time of insertion and 4 alumina abutments and 3 zirconia abutments fractured after crown cementation. Although none of the studies reported fracture of zirconia abutments at the time of insertion, this incidence cannot be ruled out and is a very important consideration in future reporting to allow true assessment of the zirconia abutments. It is important to note that no abutment fractures were reported on titanium or cast metal abutments. Because

TABLE 4. Summary of 27 included studies with their clinical outcomes

Study name	Nature of abutment and material	Mechanical complications	Biological complications	Esthetic complications	Nature of restoration	Crown material	Prosthetic complications
Camargos *et al.*[1]	Prefabricated titanium abutment and UCLA-type cast metal abutment	Abutment screw loosening (3 UCLA-type cast metal abutments)	Not reported	Not reported	One-piece screw-retained, two-piece screw-retained, and cement-retained	Metal-ceramic and metal-acrylic resin	Prosthetic screw loosening
Cabello *et al.*[2]	UCLA-type cast metal abutment and prefabricated zirconia abutment	Abutment screw loosening (1 abutment)	None	None	One-piece screw-retained (12) and cement-retained (2)	Metal-ceramic and zirconia-ceramic	None
Hosseini *et al.*[3]	UCLA-type cast metal abutment (38) prefabricated zirconia abutment (19) and prefabricated titanium abutment (11)	None	Fistulas because of residual cement in cement-retained crowns	None (although the mucosal discoloration of zirconia abutments was lesser than titanium abutments)	Cement-retained	Metal-ceramic, zirconia-ceramic, and lithium disilicate	Loss of retention of one metal-ceramic crown, poor-marginal adaptation of one all-ceramic crown, and minor chipping of porcelain of one crown
Canullo and Götz[4]	Prefabricated titanium abutment	Not reported	Plasma cleaning treatment of titanium abutments favored hard tissue levels	None	Cement-retained	Metal-ceramic	Not reported
Kim *et al.*[5]	Prefabricated alumina-toughened zirconia abutment	Abutment fracture (1) and abutment screw loosening (1 abutment)	None	Not reported	One-piece screw-retained and cement-retained	Metal-ceramic and zirconia-ceramic	Not reported
Furze *et al.*[6]	CAD-CAM zirconia abutment	None	None	None	Cement-retained	Zirconia-ceramic	Multiple fractures of provisional abutment
Gallucci *et al.*[7]	Prefabricated titanium abutment coupled with In-ceram alumina or cast gold alloy	None	None	None	Two-piece screw-retained	Metal-ceramic and In-ceram alumina	Minor chipping of porcelain (2)
Happe *et al.*[8]	Customized zirconia abutment with fluorescent orange ceramic collar	Not reported	Not reported	Minimal discoloration between peri-implant mucosa and the natural tooth gingiva.	Cement-retained	Zirconia-ceramic	Not reported
Cosyn *et al.*[9]	Prefabricated titanium abutment	None	Midfacial recession of mucosa	None	Cement-retained	Metal-ceramic	Loss of retention of one metal-ceramic crown

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Ekfeldt *et al.*[10]	CAD-CAM zirconia abutment	Fracture of the abutments (2) (one at insertion and one after 2 months); abutment screw loosening (1)	Fistulas because of residual cement in cement-retained crowns	None	One-piece screw-retained and cement-retained	Zirconia-ceramic and alumina-ceramic	Minor chipping of porcelain (three crowns), loss of retention (one crown)
van Brakel *et al.*[11]	Experimental titanium and zirconia abutments	Not reported	Not reported	Soft tissue discoloration was similar for metal and ceramic abutment when tissue thickness was greater than 2 mm	Did not place a restoration	Did not place a crown	N/A
Bressan *et al.*[12]	UCLA-type cast metal abutment (20), prefabricated CAD-CAM zirconia abutment (20), and CAD-CAM titanium abutment (20)	Not reported	Not reported	Soft tissue discoloration was least for zirconia followed by gold and then titanium abutments	Cement-retained and screw-retained	Zirconia-ceramic	N/A
Redemagni *et al.*[13]	Customized concave titanium and customized concave zirconia abutments	None	None, but the concave abutments showed minimal recession and stable soft tissue levels	None	Cement-retained	Zirconia-ceramic	None
Zembic *et al.*[14]	CAD-CAM titanium and CAD-CAM zirconia abutments	None	None	None	Cement-retained and one-piece screw-retained	Metal-ceramic and zirconia, alumina, or glass-ceramic	Minor chipping of porcelain
Jemt[15]	Prefabricated titanium abutments	Multiple abutment screw loosening (exact site and number not reported)	Buccal fistulas and buccal mucosal recession	None	One-piece screw-retained (16) and externally cemented crowns with single abutment screw (21)	Metal-ceramic	None
Lee and Hasegawa[16]	Prefabricated zirconia abutment with a titanium interface ring	None	None	None	Cement-retained	Zirconia-ceramic	None
Chen *et al.*[18]	Prefabricated alumina and zirconia abutment	Alumina abutment fractures (2)	None	None	Cement-retained	Empress II	Loss of retention (2) and crown fracture (1)
Cooper *et al.*[17]	Prefabricated titanium abutments	None	Tenderness of buccal mucosa and peri-implant mucosal defect	None	Cement-retained	Not reported	Loss of retention of two metal-ceramic crown and minor chipping of porcelain (3)
Rompen *et al.*[19]	CAD-CAM titanium and zirconia abutment	None	None	None	Cement-retained	Alumina-ceramic	Not reported

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TABLE 4. Continued

Study name	Nature of abutment and material	Mechanical complications	Biological complications	Esthetic complications	Nature of restoration	Crown material	Prosthetic complications
Canullo[20]	CAD-CAM zirconia abutment on a prefabricated titanium base	None	None	None	Cement-retained	All-ceramic material (exact type not reported)	Minor chipping of porcelain (1)
Zarone *et al.*[21]	Prefabricated titanium abutments and CAD-CAM alumina abutments	None	None	None	Cement-retained	Procera all-ceram alumina	Minor chipping of porcelain (1)
Glauser *et al.*[22]	Customized experimental zirconia abutments by manually guided copy-milling machine	Abutment screw loosening (2)	None	None	Cement-retained	Empress I	Minor chipping of porcelain (2)
Henriksson and Jemt[23]	CAD-CAM alumina abutment	None	Buccal fistulas (1) and buccal mucosal recession (2)	None	One-piece screw-retained and cement-retained	Alumina crowns and porcelain directly veneered to alumina abutment	None
Andersson *et al.*[24]	Prefabricated titanium abutments and alumina abutments	Fracture of alumina abutments (2 during the first year; 4 fractures at placement and 2 chipping at placement)	Papillary recession and buccal fistula	None	One-piece screw-retained and cement-retained	Metal-ceramic, titanium-veneered with ceramic, and all-ceramic	Fracture of all-ceramic crown (1) placed on titanium abutment
Levine *et al.*[26]	Prefabricated titanium abutments	None	Not reported	Not reported	Two-piece screw-retained and cement-retained	Metal-ceramic	Prosthetic screw loosening
Jemt[25]	Prefabricated titanium abutment	Abutment screw loosening (1)	Buccal fistula (1)	None	One-piece screw-retained	Titanium veneered with ceramic	None
Avivi-Arber and Zarb[27]	Prefabricated titanium abutment and UCLA-type cast metal abutment	Abutment screw loosening, abutment screw fracture	Buccal fistulas (3), inflammation (6) and buccal mucosal recession (1)	None	Cement-retained and screw-retained	Metal-ceramic and metal-acrylic resin	Loss of retention of metal-ceramic crown and fracture of porcelain

CAD-CAM = computer-aided design–computer-aided manufacturing; N/A = not applicable; UCLA = University of California Los Angeles.

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TABLE 5. Summary of 27 included studies with quantitative data

Study name	Number of patients	Total number of implants in the study	Total number of abutments in the study	Number of anterior abutments in the study	Total failures reported	Total mechanical complications reported	Range of follow-up in years
Camargos *et al.*[1]	44	73	73	23	0	3	2 to 13 years
Cabello *et al.*[2]	14	14	14	14	0	1	1 year
Hosseini *et al.*[3]	59	98	98	68	0	0	3 years
Canullo and Götz[4]	5	5	5	5	0	0	1.5 years
Kim *et al.*[5]	213	611	611	60	1	1	0.08 to 12.8 years
Furze *et al.*[6]	10	10	10	9	0	0	1 year
Gallucci *et al.*[7]	20	20	20	20	0	0	2 years
Happe *et al.*[8]	12	12	12	12	0	0	N/A
Cosyn *et al.*[9]	25	25	25	25	0	0	1–3 years
Ekfeldt *et al.*[10]	130	185	185	165	2	1	Variable range up to 5 years
van Brakel *et al.*[11]	11	15	30	30	N/A	N/A	N/A
Bressan *et al.*[12]	20	20	60	60	N/A	N/A	N/A
Redemagni *et al.*[13]	28	33	33	13	0	0	0.5 to 4.1 years
Zembic *et al.*[14]	22	40	40	4	0	0	2.6 to 4.4 years
Jemt[15]	35	41	41	37	0	Not reported	10 years
Lee and Hasegawa[16]	9	9	9	9	0	0	1 year
Chen *et al.*[18]	23	35	35	35	2	0	1 to 4 years
Cooper *et al.*[17]	39	43	43	43	0	0	3 years
Rompen *et al.*[19]	41	54	54	44	0	0	1 to 2 years
Canullo[20]	25	30	30	16	0	0	3 to 3.6 years
Zarone *et al.*[21]	44	58	58	58	0	0	4 years
Glauser *et al.*[22]	27	54	54	39	0	2	4 years
Henriksson and Jemt[23]	20	24	24	23	0	0	1 year
Andersson *et al.*[24]	75	89	89	70	6		1 to 3 years
Levine *et al.*[26]	110	157	157	22	0	0	2 years or more
Jemt[25]	14	17	17	16	0	1	2 years
Avivi-Arber and Zarb[27]	41	49	49	31	0	Not reported	1 to 8 years

N/A = not applicable.

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of paucity of data, the outcomes of abutments used in the anterior mandible and for fixed partial dentures remain unknown.

Mechanical Outcomes

Irrespective of the abutment material, abutment screw loosening was the most commonly reported mechanical complication; this was primarily noted in studies using external hex implants for single implant restorations. This finding is consistent with the systematic review of Sailer and colleagues.[33] Although abutment screw loosening may not be a catastrophic failure, repeated screw loosening can affect the success of implant therapy and patient satisfaction. Therefore, it may be preferable to use implants with internal connection for single implant restorations, which showed very minimal abutment screw loosening in this systematic review. The number of abutment screw fractures was minimal across all studies. The most common mechanical complication of restorations over the implant abutments was minor chipping of porcelain and loss of retention of cemented crowns possibly because of use of temporary cement. These minor complications were noted irrespective of the material of the crown.

There were two studies identified in this systematic review that described a combination of zirconia and titanium abutments (zirconia-titanium hybrid abutment). One study described the use of a thin titanium ring over the zirconia abutment at the point of interface with the implant.[16] Another study described a titanium base onto which a customized zirconia core was cemented.[22] However, there were no clinical studies identified in this systematic review that described the differences in mechanical or esthetic outcomes of complete zirconia abutments and zirconia-titanium hybrid abutment. A couple of recent in vitro studies have examined wear of the softer titanium intaglio surface of implants because of the harder zirconia abutments.[68,69] These studies have expressed concern about deterioration of the intaglio surface of the titanium implant and potential for future complications. These preliminary observations are not yet clinically validated but require future research. On the other hand, the strength and performance of the chemical and mechanical bond between the zirconia and titanium components in these hybrid abutments may also be of additional concern.

Biological Outcomes

Buccal fistulas were reported by 6/27 studies and involved both screw- and cement-retained restorations. In screw-retained restorations, this was only seen in external hex implants probably because of a gap between an ill-fitting abutment and implant, where soft tissue could have invaginated to result in fistulas. In cement-retained restorations, the fistulas were attributed to uncleaned residual cement. In all studies, the complication was resolved by appropriate intervention. Another biological complication reported in six studies was peri-implant mucosal recession. This complication was predominantly reported in studies using prefabricated titanium abutments. This association could be purely coincidental or probably related to the fact that (1) prefabricated abutments provide less optimal support of gingival tissues compared with customized abutments, (2) titanium abutments have been reported in more studies because of their longer period of usage, and (3) recession related to titanium abutments can more easily be seen and recorded compared with ceramic abutments. All other biological surrogate treatment outcomes such as plaque index, marginal bone loss, and tissue health were unremarkable irrespective of the type of abutment used. This finding is consistent with a systematic review by Sailer and colleagues who reported no differences in biological outcomes between metal and ceramic abutments.[33]

Two studies investigated the use of experimental concave-shaped implant abutments and their effect on gingival level. Rompen and colleagues[19] used 49 concave titanium abutments and 5 concave zirconia abutments on 54 implants for single crown restorations. Digital photographs were made at 1, 3, 6, 12, 18, and 24 months, enlarged and vertical changes in soft tissue levels were measured, and the definitive esthetic result was evaluated subjectively on a scale. Their results showed that 87% of the sites showed facial soft tissue stability or a vertical gain, whereas recession in the

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remaining 13% of the sites was never greater than 0.5 mm. These results suggested that using concave transmucosal profiles for implant components allowed for more predictable soft tissue stability in esthetic areas. There was no difference in soft tissue stability between titanium and zirconia concave abutments. Redemagni and colleagues[13] used 28 concave complete zirconia abutments on implants for single crown restorations. Digital photographs were made, and patients were followed for a mean interval of 20.8 months. Their results were similar to Rompen and colleagues,[19] and concluded that buccal gingival soft tissues showed minimal recession, stability, and increased volume of connective tissue. Long-term data with a randomized, controlled design are needed to validate this promising design of implant abutments.

Esthetic Outcomes

Esthetic outcomes in general pose challenges for comparison of treatment outcomes across populations and studies. This is obviously because of variations in subjective assessments not only among clinicians but also because of variations between clinicians and patients. The predominant esthetic outcome attributable to the abutment in anterior implant restorations is the change in color of the peri-implant soft tissues. Previous authors have implicated that the blue-grayish shimmering effect of titanium abutments, especially over thin peri-implant mucosal tissues can compromise the esthetic result.[3,28,70,71] This was one of the primary reasons for development of alumina and zirconia abutments.[22,30–32]

There were 4 randomized, controlled trials (RCTs) identified in this systematic review, and 3 of them compared esthetic outcomes between metal and ceramic abutments. Andersson and colleagues[24] in a multicenter trial compared prefabricated alumina abutments (test group) against prefabricated titanium abutments (control group) on 70 anterior abutments on external hex implants. The majority of abutments were in the anterior maxilla. For alumina abutments, either all-ceramic crowns were cemented over them or porcelain was fused directly to the abutment to result in a one-piece screw-retained restoration. For titanium abutments, either all-ceramic crowns or metal-ceramic crowns were cemented over them. Although this study did not report many tenets of an RCT such as allocation concealment, follow-up, and control of bias, it was reported that all patients in the test and control groups were fully satisfied with the achieved esthetic results at the 1-year follow-up. However, there was no mention of change in color of peri-implant soft tissues because of either abutment. Zembic and colleagues[14] compared CAD-CAM fabricated zirconia abutments against CAD-CAM fabricated titanium abutments in an RCT, which included only four anterior abutments that were all on canine sites. For zirconia abutments, either all-ceramic crowns were cemented over them or porcelain was fused directly to the abutment to result in a one-piece screw-retained restoration. For titanium abutments, metal-ceramic crowns were cemented over them. The difference of color (delta E) of the peri-implant mucosa as well as the gingiva of control natural teeth was assessed with a spectrophotometer over all abutments. They reported that both zirconia and titanium abutments induced a visible discoloration of the peri-implant soft tissues compared with the gingiva of the control teeth. The amount of discoloration induced by zirconia and titanium abutments was not significantly different. Gallucci and colleagues[7] compared titanium abutments with an in-ceram ceramic coping (test group) against titanium abutments (control) in 20 patients, all of whom were indicated for two-piece screw-retained restorations. Although the test group abutments received a ceramic veneering, the control group received a metal-ceramic crown. Specific subjective and objective criteria were used for esthetic evaluation by independent clinicians and patients. Their results showed that metal-ceramic and all-ceramic restorations were indistinguishable from each other and the investigator's concluded that the choice of material *per se* does not ensure an optimal esthetic outcome.

Four additional observational studies identified in this systematic review examined the peri-implant mucosal discoloration because of abutments.[3,8,11,12] Bressan and colleagues[12] compared three types of abutments (CAD-CAM titanium, cast gold alloy, and CAD-CAM zirconia) on each of 20 patients in a random fashion.

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An all-ceramic crown was temporarily cemented over each of the abutments to simulate a clinical situation. A spectrophotometer was then used to measure peri-implant mucosal color changes for each abutment and mucosa adjacent to a contralateral natural tooth. Their results showed that all three abutments induced a color change in the peri-implant mucosa that was different than the natural tissue color, but zirconia abutments induced the least color change, which was not significantly different than the cast gold abutment. However, titanium abutments were associated with significantly higher differences in color. They also concluded that the thickness of the peri-implant tissues was not a crucial factor for color change. van Brakel and colleagues[11] compared two types of specially designed abutments (titanium and zirconia) that were not intended for clinical use. They compared both abutments on each of the 15 implants and used spectrophotometric measurements at each of the abutments. Their results showed that the difference in peri-implant mucosal discoloration between zirconia and titanium abutments was imperceptible to the human eye when the mucosal thickness was greater than 2 mm. They also stated that the peri-implant mucosa in general is about 2 mm thick when measured 1 mm below the gingival margin. However, some methodological issues in this study limit its clinical applicability. First, the experimental abutments used were not representative of clinical conditions; second, no crown was placed over the abutment before spectrophotometric measurements were made; and finally, the spectrophotometric measurements only compared differences in tissue color between titanium and zirconia abutments but not between natural tissues before abutment placement or natural tissues on the contralateral side.

Happe and colleagues[8] used spectrophotometric measurements on 12 implant abutments to compare a specially fabricated zirconia abutment against the natural gingival tissue of unrestored adjacent or contralateral natural teeth. The zirconia abutment had been veneered with a 2 mm wide collar of an experimental fluorescent light orange ceramic material. They concluded that there were minimal differences in the peri-implant mucosal color between the implant abutment sites and the natural teeth sites. Hosseini and colleagues[3] in a 3-year prospective study including 68 anterior implants with cast metal, titanium, and zirconia abutments used clinician and patient's subjective analysis to analyze esthetic outcomes. Although the peri-implant mucosal discoloration was not significantly different between metal and zirconia abutments, slightly less discoloration was noted by clinicians at sites with zirconia abutments. In general, patients reported no difference in esthetic satisfaction of all-ceramic and metal-ceramic restorations.

Another specific study that was excluded in this systematic review because of lack of retrievable data on anterior abutments, but is applicable for discussion on this topic, is an RCT by Jung and colleagues.[41] They used a spectrophotometer to compare the color difference in peri-implant mucosa before and after insertion of a metal abutment (titanium or cast gold alloy) and an alumina abutment. Alumina all-ceramic crowns were cemented over the alumina abutments, and metal-ceramic crowns were cemented over the metal abutments. They also compared the mucosal color difference at each implant site and a corresponding neighboring natural tooth site. Like previous studies, their results showed that there was a difference in color of the peri-implant mucosa before and after insertion of all types of abutments, without any significant differences. However, when the mucosal discoloration induced by each abutment was compared with the mucosa around natural teeth sites, the alumina abutments showed lesser discoloration than the metal abutments, and this difference was significant.

In summary, it appears that studies using spectrophotometric analysis showed higher sensitivity to detect peri-implant mucosal discoloration, whereas studies using subjective/objective scoring criteria reported minimal differences in esthetic outcomes and patient satisfaction. Future studies should examine the validation of spectrophotometry with respect to clinician and patient-reported esthetic outcomes and treatment satisfaction.

The focused question of this systematic review using the patient-intervention-control-outcome (PICO)

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format was: in patients requiring anterior implant restorations, does use of a specific abutment (metal or ceramic) have better survival, mechanical, biological, and esthetic treatment outcomes? Systematic reviews of RCTs are generally considered to offer the highest level of evidence for decision making in clinical practice.[72] However, depending upon on the nature of the focused question in a systematic review, RCTs might not always be available for analysis. This is generally common in implant dentistry where it is difficult to perform RCTs, given the nature of the treatment, cost, and the limited opportunity for randomization. Therefore, observational studies may also need to be incorporated into a systematic review to help better answer the focused question by assessment and summarization of all existing data.[73] They also aid in highlighting the deficit in the existing body of knowledge and help to guide future research.

Like any systematic review, there are some limitations to this study. First, there could be multiple implant abutments whose outcomes were unaccounted for mainly because of omission of those studies from which data could not be extracted. This is primarily because of the manner of data reporting by the authors of those studies where anterior and posterior abutments were grouped together or studies where the outcomes were not reported at all. Moreover, some studies defined the anterior region up to the second premolar teeth but did not provide specific number of abutments for each implant site, making it impossible to isolate the data, and therefore, such studies were excluded. The authors of this systematic review defined the anterior region as canine to canine with the previously described rationale of significantly different occlusal forces from anterior to posterior region. It is important that future studies on implant abutments differentiate anterior and posterior abutments, and describe number of abutments followed for different time intervals. Such long-term studies with adequate sample sizes will allow better understanding of clinical outcomes of various abutments.

CONCLUSIONS

1. Minimal fractures have been reported for implant abutments in the anterior region, but this data is primarily derived from short-term research on implant-supported single crowns. There is limited data for anterior implant-supported fixed partial dentures. No data could be assimilated for long-term survival of abutments because of heterogeneity of reporting.
2. Among all fractures, the highest fractures were reported for alumina abutments followed by zirconia abutments. There are no reported fractures on titanium and cast metal alloy abutments for the anterior region.
3. Irrespective of the type of abutment, screw loosening was the most common mechanical complication, but this finding is derived primarily from studies using external hex implants. Loss of retention for cemented crowns and minor chipping of porcelain were the most common prosthetic complications reported.
4. Buccal fistulas and mucosal recession were the most common biological complications and were reported in screw-retained and cemented restorations.
5. Clinical studies using spectrophotometric analysis showed lesser peri-implant mucosal discoloration with zirconia abutments, but there is no evidence for difference in patient's esthetic satisfaction between ceramic and metal abutments.

DISCLOSURE

The authors have no financial interest in any of the companies whose products may be included in this paper.

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Reprint requests: Avinash S. Bidra, BDS, MS, University of Connecticut Health Center, 263 Farmington Avenue, L6078, Farmington, CT 06030, USA; email: avinashbidra@yahoo.com

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