

Group 2 ITI Consensus Report: Prosthodontics and implant dentistry

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**Abstract**

Objectives: Working Group 2 was convened to address topics relevant to prosthodontics and dental implants. Systematic reviews were developed according to focused questions addressing (a) the number of implants required to support fixed full-arch restorations, (b) the influence of intentionally tilted implants compared to axial positioned implants when supporting fixed dental prostheses (FDPs), (c) implant placement and loading protocols, (d) zirconia dental implants, (e) zirconia and metal ceramic implant supported single crowns and (f) zirconia and metal ceramic implant supported FDPs.

Materials and methods: Group 2 considered and discussed information gathered in six systematic reviews. Group participants discussed statements developed by the authors and developed consensus. The group developed and found consensus for clinical recommendations based on both the statements and the experience of the group. The consensus statements and clinical recommendations were presented to the plenary (gathering of all conference attendees) and discussed. Final versions were developed after consensus was reached.

Results: A total of 27 consensus statements were developed from the systematic reviews. Additionally, the group developed 24 clinical recommendations based on the combined expertise of the participants and the developed consensus statements.

Conclusions: The literature supports the use of various implant numbers to support full-arch fixed prostheses. The use of intentionally tilted dental implants is indicated when appropriate conditions exist. Implant placement and loading protocols should be considered together when planning and treating patients. One-piece zirconia dental implants can be recommended when appropriate clinical conditions exist although two-piece zirconia implants should be used with caution as a result of insufficient data. Clinical performance of zirconia and metal ceramic single implant supported crowns is similar and each demonstrates significant, though different, complications. Zirconia ceramic FDPs are less reliable than metal ceramic. Implant supported monolithic zirconia prostheses may be a future option with more supporting evidence.

KEYWORDS

ceramic crown, ceramic fixed dental prosthesis, full-arch prosthesis, implant loading, implant number, implant placement, implant survival, patient outcomes, tilted implants, zirconia implants

1 | INTRODUCTION

Prosthodontic treatment assisted by dental implants has continued to evolve and is a routine option for clinicians and patients. There are, however, questions that remain for newer treatment protocols.

For treatment of edentulous arches, the appropriate number of implants required to support a prosthesis and the influence of implant inclination remain controversial. Systematic reviews conducted by Polido et al. and by Lin and Eckert analysed and compared the implant number and inclination, respectively. For partially dentate (or edentate) arches, placement and loading protocols continue to develop. Subsequent to a systematic review of the existing literature on this

topic, Gallucci et al. consider the state of the science, and propose a comprehensive classification and treatment philosophy that considers placement and loading as a singular planning and treatment decision.

Material options continue to expand for fabrication of both dental implants and prostheses. A systematic review conducted by Roehling et al. investigated the state of the science associated with dental implants fabricated from zirconia and compared the performance of zirconia implants with those fabricated from titanium. Systematic reviews by Pjetursson et al., and Sailer et al. analysed the performance of zirconia ceramic when compared to metal ceramic restorative materials for the restoration of implants in single tooth sites and extended edentulous spans, respectively.

When developing consensus statements, the group chose to include the number and type of citations from which conclusions were drawn for the benefit of the reader.

The six systematic reviews undertaken by this group include:

- 1 Clinical performance of intentionally tilted implants versus axially positioned implants: A systematic review.
Wei-Shao Lin and Steven E. Eckert.
- 2 Implant placement and loading protocols in partially edentulous patients: A systematic review.
German O. Gallucci, Adam Hamilton, Wenjie Zhou, Daniel Buser and Stephen Chen.
- 3 Performance and outcomes of zirconia dental implants in clinical studies: A meta-analysis.
Stefan Roehling, Karl A. Schlegel, Henriette Woelfler and Michael Gahlert.
- 4 Number of implants placed for complete arch fixed prostheses: A systematic review and meta-analysis.
Waldemar Daudt Polido, Tara Aghaloo, Thomas W. Emmett, Thomas D. Taylor and Dean Morton.
- 5 A systematic review of the survival and complication rates of zirconia-ceramic and metal-ceramic multiple-unit fixed dental prostheses.
Irena Sailer, Malin Strasding, Nicola Alberto Valente, Marcel Zwahlen, Shiming Liu and Bjarni Elvar Pjetursson.
- 6 A systematic review of the survival and complication rates of zirconia-ceramic and metal-ceramic single crowns.
Bjarni E. Pjetursson, Nicola A. Valente, Malin Strasding, Marcel Zwahlen, Shiming Liu and Irena Sailer.

1.1 | Disclosures

All participants were asked to disclose any possible conflicts of interest that could potentially influence the direction of the consensus deliberations. No conflicts of interest were identified.

2 | NUMBER OF IMPLANTS PLACED FOR COMPLETE ARCH FIXED PROSTHESES: A SYSTEMATIC REVIEW AND META-ANALYSIS

2.1 | Preamble

Varying numbers of implants have been reported in the literature as being used to supported fixed full-arch prostheses for completely edentulous arches. Many factors are reported to influence the decision regarding the number of implants chosen. This systematic review was designed to evaluate surgical and prosthetic outcomes associated with five or more implants, and compare these with using less than five implants, when

providing full-arch fixed prostheses for completely edentulous arches. Primary outcomes investigated were implant and prosthesis survival. Secondary outcomes included distribution of implants, implant inclination, loading protocol and mode of prosthesis retention.

2.2 | Consensus statements

1. There is no statistically significant difference in implant survival rates associated with the use of fewer than five implants when compared to five or more implants when supporting a fixed dental prosthesis. This statement is based on outcomes reported in 93 studies (9 RCTs, 42 Prospective and 42 Retrospective) with a median follow-up of 8 years (range: 1–15 years).
2. There is no statistically significant difference in outcomes (implant and prosthesis survival) for full-arch FDPs in the maxilla supported by fewer than five implants (median follow-up of 5.5 years) when compared to five or more implants (median follow-up of 8 years). This statement is based on the analysis of data from 50 groups of patients, extracted from the 28 studies that reported numbers of implants for the maxilla (1 RCT, 13 Prospective and 14 retrospective), and from the 19 papers that reported for both groups (3 RCT, 7 Prospective and 9 Retrospective), among which 26 reported on fewer than five implants, and 24 reported on five or more implants. In all, 47 publications reported outcomes for the maxilla (4 RCTs, 20 Prospective and 23 Retrospective). Of the 26 studies documenting outcomes for fewer than five implants, the majority reported on the use of four implants incorporating distally tilted posterior implants and an immediate loading protocol (23 reports with a median follow-up of 5.5 years). A majority of the 24 studies documenting outcomes for five or more implants reported use of six implants positioned in a parallel configuration and utilizing an immediate loading protocol (20 reports with a median follow-up of 8 years).
3. There is no statistically significant difference ($p < 0.05$) in outcomes (implant and prosthesis survival) for full-arch FDPs in the mandible supported by less than five implants (median follow-up of 5.5 years) when compared to five or more implants (median follow-up of 5.5 years). This statement is based on the analysis of data from 72 groups, among which 58 reported on fewer than five implants and 14 reported on five or more. Data were extracted from 65 publications that reported on the mandible (8 RCT, 29 Prospective and 28 Retrospective). Of the 14 studies documenting use of five or more implants to support a complete arch prosthesis in the mandible, a majority used five implants (10 reports with a median follow-up of 4 years) in a parallel configuration (12 reports) and with an immediate loading protocol (8 reports). Of the 58 studies documenting use of fewer than five implants, a majority used four implants (41 studies with a median follow-up of 5.5 years and a range of 1–10 years). A parallel configuration was reported in 27 papers and use of posterior distally inclined implants reported in 31. An immediate loading protocol was reported as being used in 48 of the 58 articles.

2.3 | Clinical recommendations

1. The final prosthetic plan should be considered when developing a surgical plan for implant treatment of edentulous arches. Factors to be considered include:
 - a. Prosthesis material
 - b. One-piece or segmented prostheses
 - c. Aesthetic factors (e.g., lip support, smile line)
 - d. Condition of the opposing dentition
 - e. Available space for the prosthesis
 - f. Anatomy of the edentulous ridge (maxilla, mandible, bone volume and quality, anatomic limitations)
 - g. Planned implant distribution (AP distribution) and cantilever length
 - h. Space available for hygiene and maintenance
 - i. Patient preference and compliance
2. When patients present with teeth in place, all treatment options should be considered as part of the informed consent process and appropriate consideration should be given to preservation of teeth. When the decision is made to rehabilitate the patient with a full-arch prosthesis, and tooth extraction is required, planning consideration must be given to the space required for the prosthesis in all dimensions.
3. A minimum number of four appropriately distributed implants are recommended to support a one-piece full-arch fixed prosthesis. However, the impact of future implant loss/complications on prosthesis support should be considered when choosing implant number. Additional implants can provide options for fixed full-arch segmented prostheses.
4. When selecting the placement and loading protocol, the following conditions should be considered:
 - a. Systemic conditions
 - b. Implant stability (insertion torque/ISQ)
 - c. The need for bone grafting at the time of placement
 - d. Implant size and shape
 - e. Experience and skill of the clinician

These modifiers should be considered for each site where an implant is planned.
5. As part of a comprehensive plan, and when clinician skill and oral environment are favourable, the invasiveness of surgery can be reduced through utilization of improved implant materials, surfaces and designs (short, narrow, tapered), prosthetic connections and placement options (tilted implants).
6. Bone augmentation is recommended when there is a need to increase implant distribution or number in response to the prosthetic plan. These procedures are more invasive and challenging, increasing the level of clinician skill and experience required.

2.4 | Recommendations for future research

1. There is a need for additional randomized clinical trials comparing use of four and six implants for support of fixed full-arch prostheses.

2. Studies comparing one-piece and segmented prostheses for the rehabilitation of edentulous arches are required.
3. Studies evaluating the influence of digital planning and guided surgical options on treatment predictability and patient outcomes are required.
4. Studies evaluating the influence of intraoral optical scanning and the use of CAD-CAM technology on full-arch prosthesis fit and patient outcomes are required.
5. There is a need for research evaluating the use of reduced diameter, short and extra-short implants when planning and treatment edentulous arches with full-arch prostheses. Randomized clinical trials comparing outcomes for these with four implants including tilted options are needed.

3 | CLINICAL PERFORMANCE OF INTENTIONALLY TILTED IMPLANTS VERSUS AXIALLY POSITIONED IMPLANTS

3.1 | Preamble

A treatment approach using intentionally tilted implants has been recommended to both reduce prosthetic cantilevers and additional surgical interventions. This review was undertaken to determine the clinical performance of dental implants that are intentionally tilted when compared to implants that are placed following the long axis of the residual alveolar ridge, when used to support full-arch fixed prostheses. Primary outcomes evaluated were implant and prosthesis survival rates. Secondary outcomes included peri-implant marginal bone loss, soft and hard tissue complications, prosthetic complications and subjective patient-centred outcomes.

3.2 | Consensus statements

1. There is no statistically significant difference in primary outcomes (survival rates for implant and prosthesis) or secondary outcomes (peri-implant marginal bone loss, soft and hard tissue complications, prosthetic complications and patient-centred outcomes) for implants placed in an axial or in a tilted configuration when used to support full-arch FDPs. This statement is based on 20 studies (2 RCTs, 1 CT and 17 Prospective Cohort).
2. The most common complications associated with an interim full-arch fixed acrylic resin prosthesis were prosthesis fracture, screw loosening and fracture of the veneering material. This statement is based on 20 studies (2 RCTs, 1 CT and 17 Prospective Cohort).
3. For definitive prostheses, metal framework fracture was uncommon. More commonly encountered complications included wear or fracture of the veneering material or artificial teeth, need for re-adaptation of prostheses to tissue to compensate for continuing resorption, abutment or prosthetic screw

loosening, prosthetic screw fracture and loss of screw access restoration. This statement is based on 21 studies (2 RCTs, 1 CT and 18 Prospective Cohort).

- The studies report satisfactory patient-reported outcomes measures. These include aesthetics, phonetics, ease of maintenance and functional efficiency. This statement is based on nine studies (1 RCT, 8 Prospective Cohort).

3.3 | Clinical recommendations

- The anterior posterior implant distribution should be maximized for full-arch FDPs. When conditions allow implants should be positioned axially. If anatomic limitations or prosthetic indications exist, the posterior implants can be intentionally tilted.

3.4 | Recommendations for future research

- Direct randomized controlled clinical trials or non-randomized comparative cohort studies with longer follow-up periods and larger study populations should be designed to specifically address the questions of implant and prosthesis performance when using intentionally tilted or axially placed implants to support full-arch FDPs.

4 | IMPLANT PLACEMENT AND LOADING PROTOCOLS. A SYSTEMATIC REVIEW

4.1 | Preamble

This systematic review evaluated the scientific evidence relating to post-extraction implant placement and timing and loading protocols combined. A validation tool was used to determine the level of scientific and clinical documentation for each combination of implant placement and loading protocols (Gallucci et al., 2009). Furthermore, patient- and site-specific criteria for selecting the placement and loading protocols were tabulated to formulate clinical recommendations. Due to the heterogeneity of the data, meta-analysis was not possible; however, descriptive analysis was completed.

4.2 | Definition of terms as described in: Implant placement and loading protocols. A systematic review

German Gallucci, Adam Hamilton, Wenjie Zhou, Daniel Buser and Stephen Chen.

Type 1A: Immediate placement plus immediate restoration/loading

Type 1B: Immediate placement plus early loading

Type 1C: Immediate placement plus conventional loading

Type 2A: Early placement with soft tissue healing plus immediate restoration/loading

Type 2B: Early placement with soft tissue healing plus early loading

Type 2C: Early placement with soft tissue healing plus conventional loading

Type 3A: Early placement with partial bone healing plus immediate restoration/loading

Type 3B: Early placement with partial bone healing plus early loading

Type 3C: Early placement with partial bone healing plus conventional loading

Type 4A: Late placement plus immediate restoration/loading

Type 4B: Late placement plus early loading

Type 4C: Late placement plus conventional loading

Due to the limitations in distinct specification of the implant placement time in many clinical studies reported, the early implant placement groups (types 2 and 3) were combined for each loading protocol (Type 2/3A, Type 2/3B and Type 2/3C).

Implant Placement protocols were defined as follows:

- Immediate implant placement: Dental implants are placed in the socket on the same day as tooth extraction.
- Early implant placement: Dental implants are placed with soft tissue healing (4–8 weeks) or with partial bone healing (12–16 weeks) after tooth extraction.
- Late implant placement: Dental implants are placed after complete bone healing, more than 6 months after tooth extraction.

Implant loading protocols were defined as follows:

- Immediate loading: Dental implants are connected to a prosthesis in occlusion with the opposing arch within 1 week subsequent to implant placement.
- Immediate restoration: Dental implants are connected to a prosthesis held out of occlusion with the opposing arch within 1 week subsequent to implant placement.
- Early loading: Dental implants are connected to the prosthesis between 1 week and 2 months after implant placement.
- Conventional loading: Dental implants are allowed a healing period of more than 2 months after implant placement with no connection of the prosthesis.

4.3 | Consensus statements

- The newly proposed classification assessing both the timing of implant placement and loading combinations allows for comprehensive treatment selection.
- Type 1A (immediate placement plus immediate restoration/loading) is a clinically documented protocol. The survival rate was 98% (median 100, range 87%–100%).
 - Type 1B (immediate placement plus early loading) is a clinically documented protocol. The survival rate was 98% (median 100, range 93%–100%).

- c. Type 1C (immediate placement plus conventional loading) is a scientifically and clinically valid protocol. The survival rate was 96% (median 99, range 91%–100%).
3. a. Type 2-3A (early placement plus immediate restoration/loading) presents clinically insufficient documentation.
- b. Type 2-3B (early placement plus early loading) presents clinically insufficient documentation.
- c. Type 2-3C (early placement plus conventional loading) is a scientifically and clinically valid protocol. The survival rate was 96% (median 96, range 91%–100%).
4. a. Type 4A (late placement plus immediate restoration/loading) is a clinically documented protocol. The survival rate was 98% (median 99, range 83%–100%).
- b. Type 4B (late placement plus early loading) is a scientifically and clinically valid protocol. The survival rate was 98% (median 99, range 97%–100%).
- c. Type 4C (immediate placement plus conventional loading) is a scientifically and clinically valid protocol. The survival rate was 98% (median 100, range 95%–100%).
5. When considering placement/loading protocols, there are factors that can prevent the accomplishing of the intended treatment. These factors include:
 - a. Patient-related factors.
 - b. Lack of primary stability.
 - c. The need for bone augmentation.
4. Immediate placement and immediate restoration/loading (type 1A) is a complex surgical and prosthodontic procedure and should only be performed by clinicians with a high level of clinical skill and experience. Type 1A protocol should only be considered when there are patient-centred advantages (e.g., aesthetic requirements, reduced morbidity), and when the following clinical conditions are met:
 - a. Intact socket walls.
 - b. Facial bone wall at least 1 mm in thickness.
 - c. Thick soft tissue.
 - d. No acute infection at the site.
 - e. The availability of bone apical and lingual to the socket to provide primary stability.
 - f. Insertion torque 25–40 Ncm and/or ISQ value >70.
 - g. An occlusal scheme which allows for protection of the provisional restoration during function.
 - h. Patient compliance.
5. Early implant placement may be considered in most clinical situations, such as sites with thin facial walls and defects, often requiring simultaneous bone augmentation procedures. Conventional loading (type 2-3C) is well documented and is recommended with early implant placement. Immediate (type 2-3A) and early (type 2-3B) loading protocols combined with early implant placement are not sufficiently well documented to be recommended as routine procedures.
6. As a planned procedure, late implant placement is the least desirable of the placement time options, due to the risk of alveolar ridge resorption and reduction in bone volume, as well as extended treatment time. When late placement is indication for patient- or site-related reasons, an alveolar ridge preservation procedure is recommended.
7. In the case of late implant placement, early loading (type 4B) and conventional loading (type 4C) are well-documented protocols and may be considered routine. Late implant placement with immediate loading (type 4A) may be considered when patient-centred advantages are present, and the criteria for immediate restoration/loading are met.

4.4 | Clinical recommendations

1. Treatment planning for implant therapy should commence once the indication for tooth extraction has been confirmed. Both the implant placement and loading protocol should be planned prior to tooth extraction. The selection of the implant placement and restoration/loading protocol should be based on achieving predictable outcomes:
 - a. Long-term hard and soft tissue stability.
 - b. Optimal aesthetics.
 - c. Reduced risk for complications.
 - d. Meet patient-specific and site-related criteria.
2. As part of the planning and consent process, alternative treatment modalities should be in place, in the event that specific intra-operative procedural criteria are not met. Implant placement and restoration/loading protocols present with different levels of clinical difficulty and overall treatment risk. When selecting treatment modalities, clinician skill and experience should match the challenges associated with the selected protocol.
3. The implant placement and loading protocol can have a negative impact on survival and success of specific selection criteria are not met, and/or execution of the clinical procedure is of insufficient quality. Careful consideration of patient-centred benefits of the different implant placement and loading protocols and the associated risks should be taken into consideration.

4.5 | Recommendations for future research

1. For future research in placement/loading protocols, it is recommended that “intention to treat” analyses are conducted and intention to treat considered as a primary outcome measure.
2. Due to the possible negative influence of the implant placement/loading protocols on the treatment outcomes, in the absence of meeting specific criteria, randomization at the level of the chosen treatment is not recommended.
3. Future research on implant placement/loading protocols is required with well-designed prospective case series with at least 5-year follow-up, which should report on both the placement and loading protocols. The specific indications, locations, selection criteria and aesthetic parameters for the different types of implant placement and loading should also be reported.

5 | PERFORMANCE AND OUTCOMES OF ZIRCONIA DENTAL IMPLANTS

5.1 | Preamble

In recent history (since 2000s), numerous zirconia implant types exhibiting different physical properties and designs have been introduced to the dental market. This systematic review was undertaken to evaluate the performance of these implants. Primary outcomes investigated included implant survival and peri-implant marginal bone loss. Secondary outcomes included implant fractures, technical complications, biologic complications and aesthetic outcomes. Upon review of the literature, it became apparent that the data should be classified into two separate groups, those currently commercially available (CA), and those no longer commercially available (NCA).

5.2 | Consensus statements

1. The published data for CA zirconia implants only allow valid statements for one-piece designs. This statement is based on nine clinical studies (8 Prospective and 1 Retrospective) including 510 implants followed for 1-year, and five clinical studies (5 Prospective) including 192 implants followed for 2 years.
2. Comparing survival rates of CA one-piece zirconia implants with published data on titanium implants, 1-year (98%) and 2-year (97%) results showed similar outcomes. This statement is based on nine clinical studies (8 Prospective and 1 Retrospective) including 510 implants followed for 1 year, and five clinical studies (5 Prospective) including 192 implants followed for 2 years.
3. The survival rates of CA one-piece zirconia implants are statistically significantly higher than NCA implants. This statement is based on 18 clinical studies (14 Prospective and 4 Retrospective) including 1,128 implants.
4. CA zirconia implants show a mean peri-implant marginal bone loss on 0.67 mm (range: 0.20–1.02 mm) after 1 year. This statement is based on seven clinical studies (6 Prospective and 1 Retrospective) including 376 implants.
5. Comparing NCA and CA zirconia implants, marginal bone loss is not statistically significantly different. This statement is based on 14 clinical studies (11 Prospective and 3 Retrospective) including 839 implants.
6. Comparing NCA and CA zirconia implants, the fracture rate of one-piece designs has reduced from 3.4% to 0.2%. This statement is based on 18 clinical studies (14 Prospective and 4 Retrospective) including 1,128 implants.

5.3 | Clinical recommendations

1. Based on available data (up to 2 years), the use of one-piece CA zirconia implants can be recommended in cases where a one-piece soft tissue level implant with a cemented prosthesis is indicated and if requested by the patient.

2. Placement of one-piece zirconia implants should be prosthetically driven according to established guidelines for the implant design.
3. When using one-piece CA zirconia implants, the difficulties relating to a submucosal prosthodontic margin, removal of cement excess and difficulty with explantation have to be considered.
4. Two-piece CA zirconia implants can only be recommended with caution due to insufficient supporting data.

5.4 | Recommendations for future research

1. More data and clinical studies are needed regarding the clinical mid- and long-term performance of CA (2nd generation) one-piece zirconia implants.
2. More clinical studies focusing on CA (2nd generation) two-piece zirconia implants are needed to provide support for use as an alternative to the limited indications given for the one-piece implant design.

6 | SURVIVAL AND COMPLICATION RATES OF ZIRCONIA CERAMIC AND METAL CERAMIC SINGLE IMPLANT SUPPORTED CROWNS

6.1 | Preamble

The aim of this systematic review was to evaluate the available scientific evidence on the survival and complication rates of veneered zirconia ceramic crowns when compared to metal ceramic implant supported crowns. The primary outcome of this review was the comparison of the survival rates of the veneered zirconia and metal ceramic crowns. Secondary outcomes reviewed were biological complication rates, technical complication rates and aesthetic failure rates.

6.2 | Consensus statements

1. Zirconia ceramic and metal ceramic implants supported SCs exhibit similar 5-year survival rates. This applies to both anterior and posterior regions. This statement is based on 36 clinical trials (22 Prospective, 14 Retrospective), reporting on 4,363 implant supported metal ceramic SCs, and 912 veneered zirconia implant-supported SCs.
2. The overall incidence of biological and technical complication is substantial (13%–16% or 1 SC out of 6) for implant supported SCs. This statement is based on 11 of the included trials (6 Prospective and 5 Retrospective).
3. There is no statistically significant difference between the 5-year biological outcomes of zirconia ceramic and metal ceramic implant supported SCs, that is, peri-implant mucosal lesions and

marginal bone loss >2 mm. This statement is based on 36 clinical trials (22 Prospective and 14 Retrospective).

4. There is no statistically significant difference in veneering ceramic chipping between the two types of implant supported SCs at 5 years. There is also no difference in other technical complications such as the incidences of fracture of the abutment, abutment screw or occlusal screw and loss of retention (cemented SCs). However, catastrophic core fractures occur significantly more often with zirconia ceramic implant supported SCs. Furthermore, abutment screw or occlusal screw loosening occurs more frequently with metal ceramic implant supported SCs. This statement is based on 36 clinical trials (22 Prospective and 14 Retrospective).
5. The risk of aesthetic failure is lower for zirconia ceramic SCs when compared to metal ceramic SCs. This statement is based on 12 clinical trials (8 Prospective and 4 Retrospective).

6.3 | Clinical recommendations

1. For anterior and posterior implant supported SCs, both metal ceramic and zirconia ceramic can be recommended.
2. The selection of the prosthetic material should be based on the aesthetic expectations and general demands of the patients.
3. Patients should be informed about the likelihood and incidence of biological and technical complications for both types of crowns, as a substantial amount of time and effort may be needed for maintenance. Patient recall visits are highly recommended to reduce the risk of failure as a consequence of complications.

6.4 | Recommendations for future research

1. Monolithic ceramic crowns or micro-veneered ceramic crowns (facial veneering not including occlusal/functional areas) may be a promising alternative; however, scientific documentation is lacking. Future randomized controlled clinical trials should address the survival and complication rates of these more recent types of ceramic SCs, giving medium- to long-term follow-up results.
2. Randomized comparative studies of different types of monolithic ceramic SCs (lithium disilicate, zirconia, hybrid materials) need to be performed giving medium to long-term follow-up results.
3. Complications should be reported in a standardized way, using established indices and ratings.
4. Fractures of ceramic SCs should exclusively refer to catastrophic fractures leading to the loss of the entire prosthesis.
5. Chipping of the ceramic should clearly be described as either:
 - a. Minor chipping—polishable
 - b. Major chipping—repairable
 - c. Catastrophic chipping—not repairable that is, failure of the prosthesis.

7 | SURVIVAL AND COMPLICATION RATES OF ZIRCONIA CERAMIC AND METAL CERAMIC MULTIPLE UNIT FDPs

7.1 | Preamble

The aim of this systematic review was evaluation of available scientific evidence on the survival and complication rates of veneered zirconia ceramic FDPs when compared to metal ceramic implant supported FDPs. The primary outcome evaluated was comparison of the survival rates of the veneered zirconia and metal ceramic FDPs. Secondary outcomes reviewed were biological complication rates, technical complication rates and aesthetic failure rates.

7.2 | Consensus statements

1. Zirconia ceramic (veneered) implant supported FDPs exhibit significantly lower 5-year survival rates than metal ceramic implant supported FDPs. This statement is based on 14 studies reporting on 932 implant-supported metal ceramic FDPs (9 Prospective, 5 Retrospective) and three studies (2 Prospective and 1 Retrospective) reporting on 175 veneered zirconia implant-supported FDPs.
2. There is a lack of detailed information in the current literature to provide a statement on the biological and technical outcomes of the zirconia ceramic and metal ceramic implant supported FDPs. This statement is based on the systematic review scrutinizing the available literature on implant supported multiple unit FDPs.
3. Significantly more zirconia ceramic implant supported FDPs fail due to material fracture than metal ceramic implant supported FDPs. This statement is based on 18 clinical trials (11 Prospective and 7 Retrospective).
4. Chipping of the veneering ceramic is a common technical complication for both types of FDPs and may lead to a need for repair or replacement of the FDP. This statement is based on 14 clinical trials (8 Prospective and 6 Retrospective).

7.3 | Clinical recommendations

1. Zirconia ceramic (i.e., veneered) implant supported FDPs cannot be recommended as a first treatment option. If utilized, the patients need to be informed about the risks for fractures of the framework and chipping of the veneering ceramic.
2. Metal ceramic, using high noble (noble metal content > or =60% and gold > or =40%) or noble (noble metal content > or =25%) alloys, should still be considered as the first option for implant supported FDPs.
3. Due to the high costs of conventional metal ceramic FDPs and frequent technical problems associated with the veneered FDPs, monolithic zirconia may be an interesting alternative. However, clinical medium- to long-term outcomes have yet to be sufficiently analysed.

7.4 | Recommendations for future research

1. Monolithic zirconia implant supported FDPs may be a promising alternative; however, the scientific documentation is lacking. Future prospective clinical trials with a medium- to long-term follow-up should address the survival and complication rates of the monolithic zirconia FDPs in general.
2. Comparative clinical studies of monolithic zirconia and metal ceramic implant supported FDPs need to be performed before clinical recommendations can be made.
3. New material combinations including alternative metal or alloys (e.g., cobalt chromium) or polymer-based implant supported FDPs should be considered in future studies.
4. Complications should be reported in a standardized way, using established indices and ratings.
5. Fractures of ceramic prostheses should exclusively refer to catastrophic fracture leading to loss of the entire prosthesis.
6. Chipping of the ceramic should be clearly described as either minor chipping (polishable), major chipping (repairable) or catastrophic chipping (not repairable) leading to failure of the prosthesis.

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