ISSN Print: 2394-7489
ISSN Online: 2394-7497
Impact Factor (RJIF): 7.85
IJADS 2025; 11(4): 158-164

www.oraljournal.com
Received: 02-07-2025
Accepted: 05-08-2025

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Evaluation of immediate placement and restoration of zirconia implants with regard to esthetic outcome in the maxillary anterior region: A systematic review

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DOI: https://www.doi.org/10.22271/oral.2025.v11.i4c.2270

Abstract
Statement of the Problem: Traditional titanium implants, while functionally reliable, may pose esthetic challenges, particularly in the anterior region, due to their metallic color and potential for soft tissue discoloration. This has prompted interest in zirconia implants as a more esthetic alternative.
Purpose: This systematic review aimed to assess the esthetic outcomes of zirconia implants placed and restored immediately in the anterior maxilla.
Materials and Methods: An extensive search of PubMed, Cochrane Library, Google Scholar, and other indexed databases was conducted, restricted to English-language studies. The selection of studies adhered to PRISMA guidelines and PICOS inclusion criteria. Two reviewers independently screened articles, evaluated methodological quality, and extracted the relevant information.
Results: The studies included in this review reported consistently favorable esthetic results for zirconia implants, assessed using indices such as the Pink Esthetic Score (PES) and White Esthetic Score (WES). Evidence supports their effectiveness when immediately placed and restored in the maxillary esthetic zone.
Conclusions: Zirconia implants present a tooth-colored, metal-free alternative with excellent esthetic potential, particularly suited for the anterior maxillary region. Their use may be considered a reliable option to conventional titanium implants in esthetically demanding cases.

Keywords: Zirconia implants, esthetic outcomes, anterior maxilla, titanium implants, immediate placement

Introduction
Following tooth extraction, a natural healing sequence occurs within the alveolar bone, which can significantly influence the outer contour of the gingival tissues.[1] Research indicates that implants placed immediately after extraction can achieve outcomes comparable to those inserted into healed bone(Jemt,1996). [2] Replacing teeth with implants in the anterior maxilla remains one of the most demanding procedures in dentistry when aiming for esthetic success (Branemark *et al*., 1969). [3] The preferred material for dental implants is commercially pure titanium, whose mechanical and biological properties are well-established and have been proven effective (Adell *et al*., 1990; Branemark *et al*., 1969; Jemt, 1996). However, growing aesthetic concerns and the increasing demand for metal-free materials in dentistry have driven the search for alternatives to titanium in implantology (Wohlwend *et al*., 1996; Heydecke *et al*., 1999; Zembic *et al*., 2009).[4,5,6] Additionally, sensitivities and allergies have been linked to the failure of dental titanium implants (Sicilia *et al*., 2008; Pigatto *et al*., 2009),[7, 8] although no clinical evidence currently supports the significance of this hypothesis (Wenz *et al*., 2008) [9].
Zirconium dioxide (ZrO_2), or zirconia, has emerged as a promising substitute. It is a biocompatible, chemically stable, and non-resorbable ceramic oxide that demonstrates favorable biological and mechanical properties. (Marx, 1993; Geis-Gerstorfer & Fässler, 1999; Piconi & Maccauro, 1999) [10, 11, 12]. Most dental-grade zirconia is manufactured as 3-5 % yttria-stabilized tetragonal zirconia polycrystals (Y-TZP) (Kelly & Denry, 2008).

Initially used in orthopedics for femoral head replacements, zirconia has shown encouraging long-term results in medicine. Despite titanium's clinical success, its grayish hue, potential soft tissue shrinkage and gingival recession can compromise esthetics. In contrast, zirconia's tooth-like color makes it particularly advantageous in visible regions.

Immediate implant placement after extraction has been associated with greater patient satisfaction (95%) compared with early (84%) or delayed (80%) protocols. In addition to fewer surgical visits, this approach helps preserve peri-implant soft tissue margins, enhancing esthetics. For patients in the esthetic zone, and those not satisfied with removable provisionals, immediate fixed restoration of single implants has become increasingly accepted, provided primary stability is achieved. Evidence suggests that immediate placement does not interfere with natural socket remodeling, which involves bundle bone resorption following extraction. This is especially important in the anterior maxilla, where the buccal wall is often thin and primarily made up of bundle bone. Studies also report that that extraction of teeth (Fickl *et al*., 2008a) [14] or immediate implant surgery via flapless technique reduces soft tissue alteration, (Blanco *et al*., 2008) [15] as less surgical trauma diminishes osteoclastic activity.

Zirconia is widely used for implant abutments in esthetically demanding sites due to its natural shade, mechanical strength, and biocompatible nature. Customized CAD/CAM zirconia abutments further support optimal soft tissue shaping, preserving papillae and maintaining gingival margins. However, repeated abutment manipulation can adversely affect peri-implant tissues. To overcome this, Fürhauser *et al*. in 2006 introduced the Copy-Abutment technique, in which definitive individualized abutments are given within days aof tooth extraction and placement of immediate implant. Non-occluding temporary crowns are then replaced after 3 to 6 months, with no need for abutment alteration.

With careful case selection, precise surgical and prosthetic techniques, and meticulous soft tissue management, immediate placement and restoration of zirconia implants in the maxillary esthetic zone can achieve highly satisfactory outcomes. However, each case should be evaluated individually, considering factors such as bone and soft tissue morphology, occlusal aspects, and patient expectations, in order to achieve the best possible esthetic result (Furhauser *et al*., 2006) [16].

The primary aim of this systematic review was to analyze the esthetic outcome of immediately placed and restored zirconia implants in the anterior maxilla.

Materials and methods

A systematic review was conducted in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. The study protocol was registered in the PROSPERO database (Registration No: CRD42024509445) to ensure transparency and avoid duplication of work.

population, intervention, comparison, and outcome (PICO):

Population: Patients with partially edentulous maxillary anterior region

Intervention: Immediately placed zirconia implants with immediate loading in maxillary anterior region will be reviewed.

Comparison: Not applicable

Outcome: Esthetic enhancement after placement of zirconia implants.

Inclusion criteria

Randomized controlled trials (RCTs), longitudinal studies, retrospective studies, and case series including at least 5 participants

- Clinical case reports
- Studies available in full-text, published in English language
- Publications between January 2010 and December 2023

Exclusion criteria

- *In vitro* or animal studies
- Review articles
- Studies available only as abstracts
- Articles not meeting the above inclusion standards

Search strategy

Study selection followed the PICOS framework. Both electronic and manual searches were performed. Printed journals available at the institutional library, including the Journal of Indian Dental Association, Journal of Indian Prosthodontic Society, Journal of Prosthetic Dentistry, and International Journal of Prosthodontics, were screened manually. Reference lists of included studies and related systematic reviews were also checked.

The electronic search covered PubMed (MEDLINE), Cochrane Central, and Google Scholar for studies published from 01/01/2010 to 31/12/2023.

A concept table was developed based on the PICOS criteria of the review question, serving as the foundation for formulating the search strategy [Table 1].

Table 1: Concept Table

Pico	Population	Intervention	Comparison	Outcome
1	Partially edentulous maxillary arches	Immediate placement and restoration of zirconia implants	Not applicable	Esthetic enhancement

Search strategy in PubMed

((((zirconia implant) AND (immediate implant)) AND (immediate implant restoration)) AND (esthetic outcome)) AND (maxillary anterior region)

Cochrane search strategy

Zirconia implant and immediate implant and immediate implant restoration and esthetic outcome and maxillary anterior region

Entry terms used in Google Scholar

1. Zirconia implants
2. Immediate implants
3. Immediate implant restoration
4. Esthetic outcome in maxillary anterior region

The search history outlined above represents the final strategy used for the databases accessed up to December 2023.

Selection of studies

Each study's title and abstract were critically evaluated by two independent reviewers. The selection criteria were applied by merging search results to remove duplicates,

screening titles and abstracts to exclude clearly irrelevant articles, retrieving full texts of potentially relevant studies, grouping multiple articles from the same study, assessing full texts for compliance with eligibility criteria, and identifying related studies.

Data extraction

"Data were independently collected by two reviewers from the included studies after screening articles from all databases. Disagreements were resolved through discussion, and in cases of conflict, a third reviewer facilitated a consensus. A list was compiled based on the extracted data. The main items included authors, year and title of the study, country, study design, sample size, participants' age group, gender, radiographic findings, clinical findings, survival rate, outcomes, results, and other relevant details. All included studies were thoroughly analyzed to extract information regarding the publication and study, participants, settings, interventions, comparators, outcome measures, study design, statistical analysis, results, and other relevant details (such as funding and conflicts of interest). Data extraction for each primary outcome was completed and accurately recorded in Excel sheets.

A descriptive summary of the selection and extraction process was prepared in accordance with PRISMA recommendations.

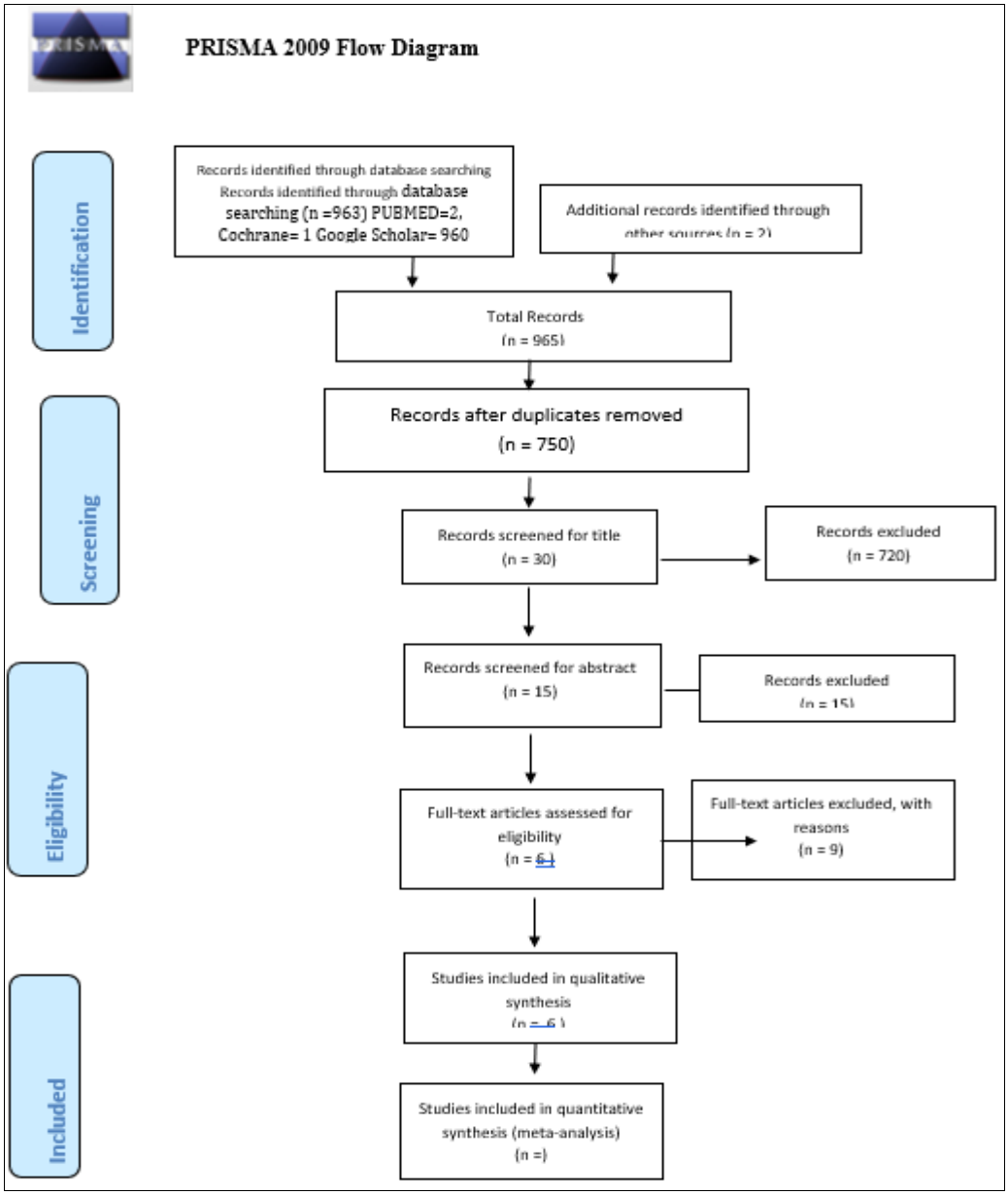

Table 2: Included studies

Study ID	Author	Year	Title
1.	Deirdre G. Beekmans	2017	Pink and White Esthetics of a New Zirconia Implant: A 6 month to 8 year Follow Up
2.	Rico Rutkowski	2022	Success and patient satisfaction of immediately loaded zirconia implants with fixed restorations one year after loading
3.	Kristian Kniha	2018	Esthetic evaluation of maxillary single tooth zirconia implants in the esthetic zone
4.	Cemal Aydın	2013	A single-tooth, two-piece zirconia implant located in the anterior maxilla: A clinical report
5.	Andrea Enrico Borgonovo	2013	Clinical evaluation of zirconium dental implants placed in esthetic areas: a case series study
6.	Stella Kiechle	2023	Evaluation of one-piece zirconia dental implants: An 8-year follow-up study

Data collection and analysis

Data were extracted from the six included studies and recorded in corresponding Excel data extraction sheets. The extracted data were entered under the following criteria: study ID, author and year of publication, study design, number of patients, patient age (range), follow-up duration (range), patients lost to follow-up, number of implants, implant type/brand, implant site, surgical protocol, zirconia implant placement and types, implant success rate, and implant esthetic outcome.

Results

The data were subsequently extracted from the six included studies and recorded in four Excel data extraction sheets, as outlined in the summary table [Table 3].

Description of selected studies

The characteristics of the included studies are presented in the tables above detailing the study characteristics. These 6 studies which were selected were retrospective clinical studies, case reports, which evaluated the esthetic outcome of immediate loading and immediate restoration of zirconia implants. The current systematic review was based on six clinical studies including a total of 170 patients and total of 316 implants, one-piece and two piece zirconia implants were placed by conventional flapped and flapless procedure and they were loaded immediately and provisional restorations were given for period of 4 to 6 months after which definitive restorations are given.

Risk of BIAS

Systematic reviews are prone to biases such as selection bias, publication bias, and information bias. Biases within individual studies can also affect the overall findings. To minimize selection bias, comprehensive searches were performed across three databases, one search engine, and relevant journals available in the institutional library. However, the review remains partly affected by selection bias due to the exclusion of grey literature and the use of an English-language filter. Each included study was assessed for key biases like inadequate reporting and misinterpretation using the MINORS and Institute of Health Economics quality assessment scales, depending on study design.

Risk of bias assessment of the included quasi-experimental studies

The quality and potential biases of the included non-randomized trials were evaluated using the Joanna Briggs Institute Critical Appraisal Checklist for Quasi-Experimental Studies. This checklist contains nine items, with responses marked as ‘yes’ for higher quality, ‘no’ for lower quality, or ‘unclear’. The percentage of bias risk was calculated based on the number of “yes” responses. Questions marked as “NA” were excluded from the calculation, in line with Joanna Briggs Institute guidelines. Scores up to 49% were classified as high risk of bias, 50-70% as moderate risk, and above 70% as low risk.

Two studies were evaluated using this checklist. The study by Rutkowski *et al*. showed a moderate risk of bias (66.7%), while the study by Kiechle *et al*. demonstrated a low risk bias (100%)

Risk of bias assessment of the included cross-sectional studies

The quality and potential biases of the included cross-sectional studies were evaluated using the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies developed by the National Heart, Lung, and Blood Institute [Ref: https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools]. This tool consists of 14 questions addressing the research objective, study population, participant eligibility, sample size details, and exposure and outcome assessment, with responses marked as ‘yes’ for higher quality and ‘no’ for poor quality.

One study by Kniha *et al*. was evaluated using this tool. The assessment with the checklist indicated a moderate risk of bias (64.3%).

Study ID	Author and year of publication	Study type	Observation period	Number of patients	Age of patient [range]	Number of implants	Implant design	Implant system and surface characteristics	Implant placement and loading technique	Prosthesis type	Pink Esthetic Score (%)	Implant success rate (%)	Implant Survival rate (%)
1	Deirdre G. Beekmans *et al* 2017 [18]	longitudinal retrospective study	6 months to 8 years	20	35-60 years	20	2 piece	White zirconia implants (Bredent, Senden, Germany)	Immediate Implant placement after extraction	Immediate implant abutment preparation and temporary restoration definitive restoration ceramic crown with Triflor glass fibre abutment	12.3	100	100
2	Rico Rutkowski *et al* 2022 [19]	retrospective clinical study	5 years	58	Above18 years	163	One-piece and two piece	SDS implants (Swiss Dental Solutions AG, Kreuzlingen, Switzerland)	Implant placement without flap and immediate loading	Immediate provisional using Luxatemp® (DMG, DMG Chemisch-Pharmazeutische Fabrik GmbH, Hamburg, Germany) or Protemp™ (3 M ESPE, 3 M Deutschland GmbH, Neuss, Germany Definitive restorations of all ceramic crowns,4 to 6 months after	12.4	88	92
3	Kristian Kniha *et al* 2018	Retrospective clinical study	4 years	52	Above 20 years	53	One-piece implants	Zirconia dioxide monotype implants (Straumann pure ceramic implants)	Implant placement with flap and immediate loading	Immediate implant abutment preparation and temporary restoration Final CAD/CAM all ceramic zirconia crowns.	17.4	100	100
4	Cemal Aydın *et al* 2013	Clinical report	1	1	23 year old	1	Two piece zirconia implant	Zit-Vario; Ziterion GmbH, Uffenheim, Germany)	Implant placement with flap and immediate loading	Immediate provisional adhesively cemented restoration All ceramic SC after 6 months		100	100
5	Andrea Enrico Borgonovo *et al* 2013	Retrospective clinical study	5 years	8	Above 20 years	12	One-piece implant	(White-SKY®, Bredent Medical)	Implant placement with flap and immediate loading	immediately restored with acrylic provisional crowns. Six months after surgery all fixtures were loaded with a final ceramic restoration	15.5	100	98
6.	Stella Kiechle *et al* 2023	prospective observational study	8 years	39	29 to 84 years old	67	One piece implant	PURE ceramic implant, Institute Straumann GmbH, Basel, Switzerland	Implant placement with flap and immediate loading	a temporary chair-side crown without occlusal contact points given immediately. Definitive prosthesis was given after 3 months	11.1	100	100

Risk of bias assessment of the included case reports

The quality and potential biases of the included case reports were assessed using the Joanna Briggs Institute Critical Appraisal Checklist for Case Reports. This checklist consists of eight questions, with responses marked as 'yes' for higher quality, 'no' for poor quality, or 'unclear'.

One study by Aydin *et al*. was evaluated using this tool. The assessment indicated a low risk of bias (87.5%).

Risk of bias assessment of the included case series:

The quality and potential biases of the included reports were assessed using the Joanna Briggs Institute Critical Appraisal Checklist for Case Series. This checklist consists of eight questions, with responses marked as 'yes' for higher quality, 'no' for poor quality, or 'unclear'.

Two studies were evaluated using this checklist. The study by Borgonovo *et al*. showed a moderate risk of bias (60%), while the study by Beekmans *et al*. showed a low risk of bias (80%).

Discussion

The present systematic review assessed the esthetic outcomes of immediate loading and immediate placement of zirconia dental implants in the maxillary anterior region. It focused on clinical studies evaluating the esthetic performance of zirconia implants after extended periods of function, unlike previous reviews that were limited to animal studies or were purely narrative.

The first included study by Deirdre *et al*. investigated the pink and white esthetics of a new zirconia implant with a follow-up period ranging from 6 months to 8 years. Briefly introduced the importance of pink (soft tissue) and white (implant and crown) esthetics in zirconia dental implants. The findings related to pink esthetics are stability of peri-implant mucosa, soft tissue health (absence of inflammation, recession, or other complications), gingival contour and color match with adjacent natural teeth. The findings related to white esthetics are longevity and survival rate of zirconia implants, stability of implant position and integration with surrounding bone, esthetic outcomes of zirconia crowns in terms of color stability and translucency. This study emphasized the importance of zirconia as a viable option for achieving both functional and aesthetic success in implant dentistry [18].

Rico Rutkowski *et al*. evaluated the success and patient satisfaction of immediately loaded zirconia implants with fixed restorations one year after loading. With a maximum follow-up of approximately 26 months, a survival rate of 92% and a success rate of 88% (Implant Quality Scale Group I) were reported. This was the first study to describe the outcome of multiple zirconia implants placed adjacent to each other and restored with splinted crowns. Immediately placed and loaded implants may offer improved esthetic outcomes, reduced bone loss, and favorable soft tissue conditions. An ideal esthetic dental rehabilitation with implants is defined as the combination of a visually appealing restoration and healthy, harmoniously contoured peri-implant soft tissue. [19]

The Pink Esthetic Score developed by Fürhauser *et al*. has been recommended for evaluating peri-implant soft tissue and esthetics due to its reproducibility and simple application [20].

Kniha *et al*. conducted an esthetic evaluation of maxillary single-tooth zirconia implants in the esthetic zone [21]. In the literature, clinical acceptability is defined as a modified PES > 6 (Pink Esthetic Score) and WES > 6 (White Esthetic Score). Unfavorable mucosal esthetics is defined as < 6 for both scores. Clinical acceptability is considered when PES + WES > 12 points. Tettamanti *et al*. concluded that PES + WES and PICI are suitable esthetic indices for single crown implants. In the present study, the total PES + WES score was 17.4 points (maximum 20). The mean PES was 8.8 points (maximum 10), and the mean WES was 8.6 points (maximum 10). All mean values were well above the threshold of clinical acceptability mentioned above [22].

Cemal Aydın *et al*. reported a clinical case of a single-tooth, two-piece zirconia implant placed in the anterior maxilla. In this clinical report, a two-piece zirconia implant was positioned in the anterior region. After 6 months, radiographic and esthetic outcomes were successful. The color of the zirconia was also attractive because of its similarity to the color of the natural tooth. However, the present clinical report evaluated only the short term performance of a new 2-piece zirconia implant; studies focusing on the long term clinical performance of zirconia implants are necessary [23].

Andrea Enrico Borgonovo *et al*. conducted a case series study evaluating zirconia dental implants placed in esthetic areas. This preliminary study reported the esthetic outcomes of 12 implants placed in the anterior region of both jaws based on the concept of early loading. After 13.5 months, the cumulative survival rate was 100%. In the literature, clinical trials on zirconia implants are limited, relatively recent, and generally report short-term follow-ups [24]. With esthetic outcome as the main objective, the average WES/PES score of 15.5 indicated overall success, ranging between 13 and 18. The PES (average 7.5) was slightly lower than the WES (average 8). This is not unexpected, as the PES is mainly influenced by local anatomy and the surgical procedures used to regenerate bone defects commonly present in postextraction implant sites. The surgeon's skill, therefore, plays a key role in achieving favorable peri-implant soft tissue esthetics [25].

Stella Kiechle *et al*. evaluated one-piece zirconia dental implants in an 8-year follow-up study. The results showed that immediate implant placement presented no visual disadvantages and no significant long-term functional limitations, with a high survival rate and low bone resorption. However, it should be noted that in their patients, the indication for immediate implant placement was determined by an experienced surgeon. These indications included absence of inflammation, adequate bone volume, absence of mucosal disease, untreated periodontitis, or gingivitis, no severe bruxism or clenching habits, and patient compliance (avoiding hard food contact with the immediate implant crown) during the 3-month healing period [26].

According to Francisco *et al* [27]. both immediate and delayed implantation methods achieved esthetic outcomes with no differences in PES. Canellas *et al*. confirmed the advantage of immediate implant placement regarding PES, particularly in the anterior region, which may be attributed to the stable hard- and soft-tissue conditions of the alveoli in this area [28].

Further studies with a larger number of implants, control groups, and extended follow-up are required to establish the true esthetic potential of this implant in the anterior jaws [29, 30].

Conclusion

Based on the findings of this systematic review, esthetic outcomes of dental implants, especially in the anterior (esthetic) zone, are highly satisfactory when evaluated using the Pink Esthetic Score (PES) and White Esthetic Score (WES). These indices consistently demonstrate that both soft tissue contour and crown morphology meet high esthetic expectations in modern implant dentistry.

Additionally, zirconia implants have emerged as a promising alternative to conventional titanium implants in esthetically demanding regions. Their tooth-like color, biocompatibility, and favorable interaction with soft tissues contribute to superior visual outcomes, especially in patients with thin gingival biotypes or high smile lines. Therefore, zirconia

implants may offer an advantage by enhancing the overall natural appearance of implant-supported restorations within the esthetic zone.

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How to Cite This Article
Mahajan S, Gopan G, Mahale K, Khalikar S, Rajguru V, Tandale U. Evaluation of immediate placement and restoration of zirconia implants with regard to esthetic outcome in the maxillary anterior region: A systematic review. International Journal of Applied Dental Sciences. 2025; 11(4): 158-164.