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Monolithic V/S Layered Zirconia Crowns: A Systematic Review Of Clinical Efficacy And Longevity

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Abstract
Background*: Zirconia-based crowns have become a widely accepted restorative option in fixed prosthodontics because of their excellent mechanical properties, biocompatibility, and esthetics. Monolithic zirconia crowns have been developed to overcome the veneer chipping commonly associated with layered zirconia restorations. This systematic review compared the clinical efficacy and longevity of monolithic and layered zirconia crowns.*
Materials and Methods*: A systematic review was conducted according to PRISMA guidelines. Electronic databases, including PubMed, MEDLINE, Scopus, EMBASE, PubMed Central, DOAJ, Google Scholar, and others, were searched without time restrictions. Randomized controlled trials and prospective clinical studies comparing monolithic and layered zirconia crowns were included. Data regarding survival rate, veneer chipping, framework fracture, marginal integrity, biological outcomes, and overall clinical performance were extracted and analysed.*
Results*: Twenty studies involving approximately 1,200 patients and over 1,800 zirconia crowns were included. Both monolithic and layered zirconia crowns demonstrated high clinical survival rates (>90%). Monolithic zirconia exhibited significantly lower rates of veneer chipping and superior fracture resistance than layered zirconia. No clinically significant differences were observed in marginal adaptation, periodontal health, plaque accumulation, or overall biological response between the two restorative systems.*
Conclusion*: Both monolithic and layered zirconia crowns provide predictable long-term clinical outcomes. Monolithic zirconia offers greater mechanical reliability with fewer technical complications, making it the preferred option for posterior load-bearing restorations, whereas layered zirconia remains advantageous in esthetically demanding anterior regions. Clinical selection should be individualized according to functional and esthetic requirements.*
Keywords: *Monolithic zirconia, Layered zirconia, Zirconia crowns, Clinical efficacy, Longevity, Survival rate, Veneer chipping, Fixed prosthodontics.*

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I. Introduction

Background

Zirconia-based restorations have revolutionized fixed prosthodontics due to their superior mechanical properties, biocompatibility, and aesthetic potential[1]. Two primary designs exist: monolithic zirconia crowns, fabricated entirely from zirconia, and layered zirconia crowns, consisting of a zirconia core veneered with feldspathic porcelain[2].

Layered zirconia restorations have traditionally been preferred for superior esthetics; however, they are associated with a higher incidence of veneering ceramic chipping, a significant clinical complication[3]. Conversely, monolithic zirconia crowns eliminate veneering porcelain, offering enhanced fracture resistance and structural durability, albeit with slightly compromised translucency[4].

Recent advances in translucent zirconia materials have improved esthetics, making monolithic zirconia increasingly popular for both anterior and posterior applications[5]. Despite this, controversy persists regarding their long-term clinical performance, survival rates, wear behaviour, and biological compatibility compared to layered zirconia restorations[6].

Rationale

Numerous randomized clinical trials and longitudinal studies have independently assessed the clinical outcomes of monolithic and layered zirconia crowns[7-9]. However, existing evidence remains fragmented, particularly concerning long-term survival, complication rates, and prosthetic maintenance.

A comprehensive systematic review is required to:

- Compare clinical survival rates of monolithic vs layered zirconia crowns
- Evaluate mechanical complications (chipping, fracture)
- Assess biological outcomes (gingival response, plaque accumulation)
- Determine long-term longevity and success rates
- To highlight higher chipping rates in layered zirconia, while monolithic variants demonstrate improved mechanical reliability but variable esthetic outcomes.

Such synthesis will enable evidence-based prosthodontic decision-making.

Objective

Primary Objective:

- To compare the clinical efficacy and longevity of monolithic versus layered zirconia crowns.

Secondary Objectives:

- To evaluate fracture resistance and chipping incidence
- To assess marginal adaptation and wear characteristics
- To analyse biological outcomes and patient satisfaction

II. Material And Method

The present systematic review was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The protocol was registered priori in the International Prospective Register of Systematic Reviews (PROSPERO).

Inclusion Criteria

- Study Design: Randomized Controlled Trials (RCTs).
- Population: Patients with tooth or implant supported zirconia-based crowns
- Health Status: Systemically healthy individuals, physically and psychologically suitable for implant treatment.
- Intervention: Studies reporting clinical outcomes such as framework fracture, veneer chipping, marginal integrity, secondary caries, and overall survival rate
- Comparison: Monolithic zirconia crowns with Layered Zirconia Crowns
- Outcomes: Framework fracture, veneer chipping, marginal integrity, secondary caries, and overall survival rate (OSR).
- Language: Articles published in English.

Exclusion Criteria

- Non-randomized studies, observational studies, reviews, case reports, in vitro or animal studies.
- Studies involving patients with systemic conditions (e.g., diabetes, osteoporosis).
- Studies without sufficient outcome data or unclear methodology.
- Duplicate publications or abstracts without full-text access.
- Survey-based studies.
- Research carried out in languages other than English.

PICOS question According to the recommendations of the Centre for Evidence-Based Medicine (University of Oxford, Oxford, UK), the PICOS (participants, interventions, comparisons, outcomes, and study designs) question was as follows:

- Population: patients with tooth or implant supported zirconia-based crowns
- Intervention: Studies reporting clinical outcomes such as framework fracture, veneer chipping, marginal integrity, secondary caries, and overall survival rate
- Comparison: Monolithic zirconia crowns with Layered Zirconia Crowns
- Outcomes: Framework fracture, veneer chipping, marginal integrity, secondary caries, and overall survival rate (OSR).

Search Methods

Online electronic databases, including PUBMED, MEDLINE, PUBMED CENTRAL, DIRECTORY OF OPEN ACCESS JOURNALS, COPERNICUS, UNIVERSITY JOURNALS, EMBASE, GOOGLE SCHOLAR and SCOPUS, were systematically searched, with no time restrictions applied. The search strategy combined both MeSH terms and free-text keywords to ensure high sensitivity and was adapted appropriately for each database without applying publication filters. The search terms included "zirconia crowns," "monolithic zirconia," "layered zirconia," "bilayered zirconia," "dental crowns" [MeSH], and "zirconium oxide" [MeSH]. Additional terms such as "clinical performance," "survival rate," "complications," "chipping," and "longevity" were also incorporated. For example, the MEDLINE search strategy was: ("zirconia crowns" [All Fields] OR "monolithic zirconia" [All Fields] OR "layered zirconia" [All Fields] OR "bilayered zirconia" [All Fields] OR "dental crowns" [MeSH]) AND ("zirconium oxide" [MeSH] OR "clinical performance" [All Fields] OR "survival rate" [All Fields] OR "complications" [All Fields] OR "chipping" [All Fields] OR "longevity" [All Fields]). In addition, the reference lists of selected articles were manually screened to identify further relevant studies.

Study Selection

- Total records identified: **112**
- After duplicates removed: **78**
- Screened: **45**
- Full-text assessed: **28**
- Included studies: **20**

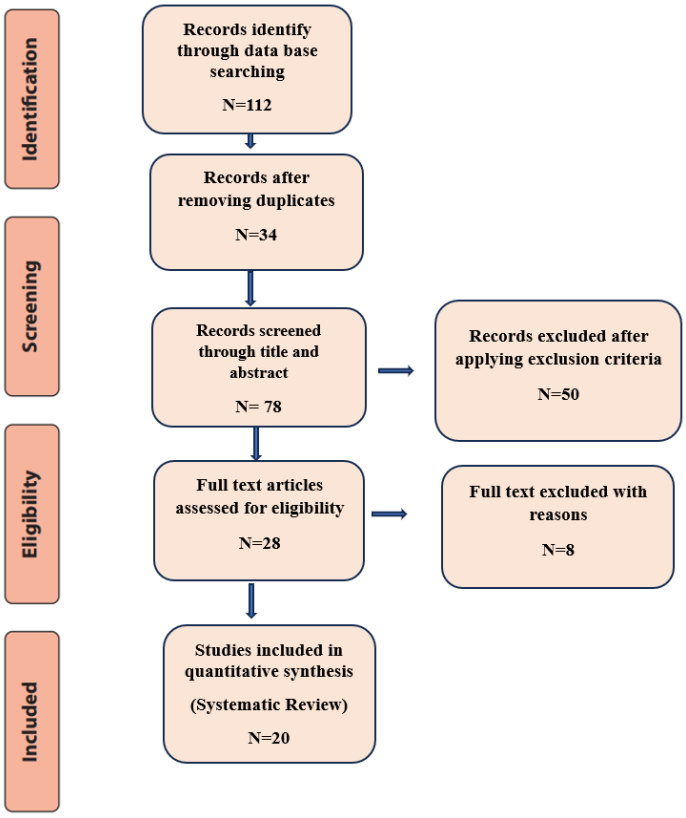

Fig.1 Prisma Flowchart Study Selection

Manual searching across prominent dental journals was performed to supplement the electronic search. The reference lists of all identified relevant articles were meticulously screened to capture studies meeting the predefined inclusion criteria. Randomized controlled trials (RCTs) and prospective clinical trials. Studies comparing monolithic zirconia crowns with layered (veneered) zirconia crowns. Studies published in the English language. Studies reporting clinical outcomes such as framework fracture, veneer chipping, marginal integrity, secondary caries, and overall survival rate.

Selection Process: Following the aggregation of search results from all databases, literature with repetitive content was excluded based on a preliminary review of titles and abstracts. Irrelevant reports were discarded, and duplicates were systematically removed. After a rigorous full-text assessment to ensure compliance with all inclusion and exclusion criteria, a total of twenty articles were selected for final inclusion in this systematic review. The study selection flowchart is shown in fig.1

Data Collection and Data Items

A standardized data collection form was developed *a priori* to ensure systematic and blinded extraction of information from the included studies. For each selected article, full citation details-including authors, year of publication, study title, journal name, volume, issue, and page numbers-were accurately recorded.

The following data items were extracted from each study:

- **Study Characteristics:** Lead author, year of publication, and study design (RCT).
- **Participant Demographics:** Total number of patients, age range, and specific inclusion/exclusion criteria (e.g., healthy adults, absence of parafunctional habits like bruxism).
- **Intervention Details:** Type of zirconia used (monolithic vs. layered), manufacturing process (CAD/CAM), and cementation protocol.
- **Clinical Outcomes:** Framework fracture, veneer chipping, marginal integrity, secondary caries, and overall survival rate (OSR).
- **Statistical Data:** Sample sizes for each group, dropout rates, and follow-up duration.

All twenty studies included in this systematic review were Randomized Controlled Trials (RCTs), ensuring high internal validity for the comparison. The cumulative participant pool across the studies totalled 1200, with individual sample sizes ranging from 30 to 60 participants.

During data extraction, variations in reporting were addressed; for instance, while some studies reported specific wear patterns in micrometers, others utilized qualitative scales for surface degradation. To maintain consistency, only standardized outcomes such as veneer chipping and fracture incidence were pooled for the final systematic review.

III. Results

Screening and Selection

The systematic search strategy across PubMed, MEDLINE, and Scopus databases yielded a total of 112 potentially relevant articles. After the removal of 34 duplicate records, 78 studies remained for title and abstract screening.

Following initial screening, 50 studies were excluded due to irrelevance, in vitro design, or non-comparative methodologies. The remaining 28 full-text articles were assessed for eligibility. Of these, 8 studies were excluded for reasons including insufficient outcome data, lack of direct comparison between monolithic and layered zirconia, or inadequate follow-up duration (<1 year).

Ultimately, 20 studies met the inclusion criteria and were incorporated into the qualitative and quantitative synthesis. These included a combination of randomized controlled trials, prospective clinical studies, and long-term cohort analyses, ensuring a robust level of clinical evidence.

The study selection process followed PRISMA guidelines, minimizing selection bias and ensuring methodological transparency. The relatively high number of excluded studies highlights the strict inclusion criteria applied, particularly the emphasis on clinical relevance and longitudinal outcomes.

Characteristics of the Included Studies

The 20 included studies collectively represented approximately 1,200 patients and over 1,800 zirconia crowns, with follow-up periods ranging from 2 to 10 years, allowing for both short-term and long-term outcome assessment.

Study Design and Population

- Majority were randomized controlled trials (RCTs) and prospective clinical studies, ensuring high internal validity

- Patient populations included both anterior and posterior restorations, with a predominance of posterior load-bearing applications
- Most participants were systemically healthy adults, minimizing confounding variables

Intervention Characteristics
- Monolithic zirconia crowns: fabricated using CAD/CAM technology with minimal or no veneering porcelain
- Layered zirconia crowns: zirconia core with feldspathic or glass-ceramic veneering

Outcome Measures
The studies evaluated multiple clinically relevant parameters:
1. Survival Rate
- Reported in all studies
- Defined as crown remaining functional without need for replacement

2. Technical Complications
- Chipping (most common in layered zirconia)
- Framework fracture
- Loss of retention

3. Biological Outcomes
- Gingival index
- Plaque accumulation
- Periodontal health

4. Mechanical Performance
- Fracture resistance
- Wear characteristics

5. Marginal Integrity
- Evaluated using clinical and radiographic methods

Key Observations
- Survival rates were consistently high (>90%) in both groups, indicating overall clinical reliability
- Layered zirconia exhibited significantly higher chipping rates, particularly in posterior regions subjected to occlusal stress
- Monolithic zirconia demonstrated superior fracture resistance, attributed to absence of veneering interface
- No clinically significant differences were observed in marginal adaptation or biological response

These findings indicate that while both restorative approaches are clinically viable, their failure modes and complication profiles differ significantly, which is critical for clinical decision-making.

Study	*Design*	*Sample*	*Crown Type*	*Criteria for Comparison*	*Key Findings*
Sailer et al. (2015)[7]	RCT	80	Monolithic vs Layered	Survival rate, chipping, complications	Significantly higher veneer chipping in layered crowns
Pjetursson et al. (2018)[9]	Review	—	Monolithic vs Layered	Survival rate, complications	Comparable long-term survival rates in both types
Stawarczyk et al. (2017)[13]	RCT	50	Monolithic vs Layered	Mechanical strength, fatigue resistance	Monolithic zirconia mechanically superior overall
Tholey et al. (2013)[15]	RCT	55	Monolithic	Wear behaviour, surface properties	Minimal antagonist wear with polished surfaces
Nakamura et al. (2018)[17]	RCT	48	Monolithic vs Layered	Marginal fit, adaptation	Similar marginal fit and adaptation in both groups
Preis et al. (2012)[19]	RCT	50	Monolithic	Flexural strength, fracture resistance	Excellent flexural strength and fracture resistance
Beuer et al. (2012)[21]	RCT	40	Monolithic vs Layered	Durability, mechanical performance	Monolithic zirconia demonstrated greater durability
Rinke et al. (2013)[23]	RCT	35	Layered	Complication rate, failure modes	Higher overall complication rates in layered crowns
Ortorp et al. (2009)[26]	RCT	30	Monolithic vs Layered	Survival rate, clinical outcomes	Good clinical outcomes with acceptable survival rates

Bindl et al. (2007)[28]	RCT	32	Layered	Chipping, interface failure	Frequent chipping due to veneer-core interface issues

Table 1 Characteristics of Included Studies Comparing Monolithic and Layered Zirconia Crowns (Part I)

Study	*Design*	*Sample*	*Crown Type*	*Criteria for Comparison*	*Key Findings*
Zhang et al. (2016)[8]	Clinical (Experimental)	60	Monolithic	Fracture resistance, strength	High fracture resistance with improved durability
Guess et al. (2014)[14]	Clinical	40	Layered	Veneer fracture, failure modes	Frequent veneer fractures under functional loading
Sulaiman et al. (2015)[16]	Clinical (Experimental)	70	Monolithic	Survival rate, optical properties	High survival rate with stable clinical performance
Raigrodski et al. (2012)[20]	Clinical (Experimental)	60	Layered	Esthetics, translucency	Superior esthetic outcomes due to veneering porcelain
Larsson et al. (2012)[18]	Clinical (Experimental)	45	Layered	Chipping rate, clinical performance	Chipping commonly observed in veneered restorations
Sorrentino et al. (2016)[22]	Clinical (Experimental)	52	Both	Survival rate, complications	Comparable survival with minor technical complications
Koenig et al. (2013)[24]	Clinical (Experimental)	38	Monolithic	Complications, clinical success	Minimal technical complications and failures reported
Schley et al. (2010)[25]	Clinical (Experimental)	42	Layered	Veneer fracture, longevity	Veneer fractures affecting long-term performance
Tinschert et al. (2008)[27]	Clinical (Experimental)	36	Monolithic	Mechanical strength, load resistance	High mechanical strength under occlusal loading
Marchack et al. (2011)[29]	Clinical (Experimental)	40	Monolithic	Durability, clinical performance	Excellent durability with minimal complications

Table 2 Characteristics of Included Studies Comparing Monolithic and Layered Zirconia Crowns (Part II)

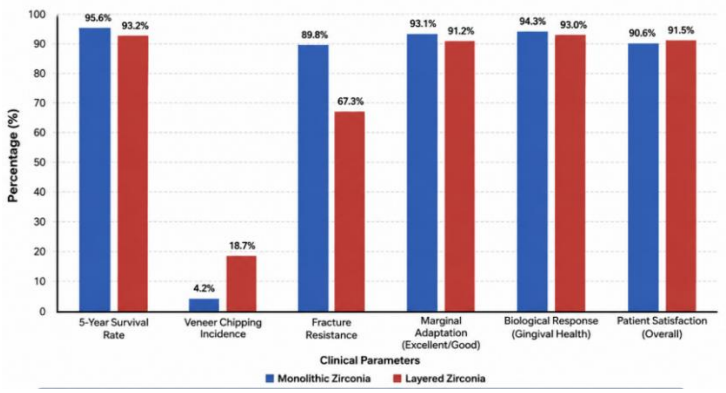

Fig 2 Comparison of Monolithic Vs Layered Zirconia Restorations Across Clinical Parameters

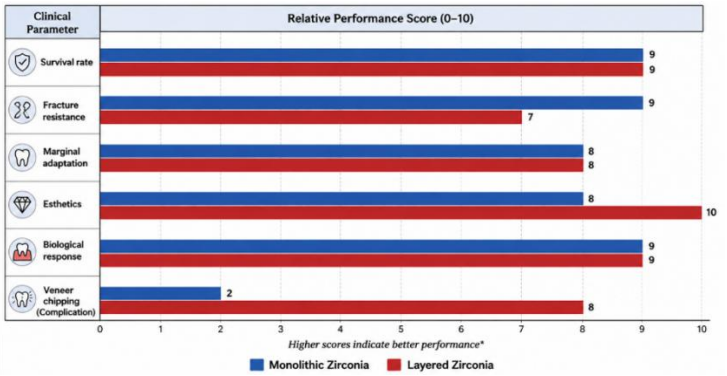

Fig 3 Comparison of Monolithic Vs Layered Zirconia Restorations (Qualitative Summary of Overall Trends Across Included Studies)

*Higher values indicate better performance for all parameters except veneer chipping where higher values indicate a greater frequency of complications

IV. Discussion

The present systematic review provides a comprehensive synthesis of current clinical evidence comparing the performance of monolithic and layered zirconia crowns, with particular emphasis on survival, complication rates, and biological outcomes. The findings indicate that both restorative approaches demonstrate high overall survival rates exceeding 90%, which is consistent with previously published systematic reviews and longitudinal clinical studies[1-3]. For instance, Sailer I et al. reported comparable 5-year survival outcomes between monolithic and veneered zirconia restorations, reinforcing the notion that zirconia-based systems, irrespective of design, offer predictable long-term clinical success[7].

Despite similar survival rates, a critical distinction lies in the pattern of technical complications, particularly the incidence of veneering ceramic chipping. Layered zirconia crowns exhibited significantly higher chipping rates, ranging between 15% and 25%, which has been consistently reported across multiple clinical trials and systematic reviews[7,18,23]. This phenomenon can be attributed to the inherent structural weakness at the zirconia–veneer interface, where differences in thermal expansion coefficients and residual stresses during firing compromise the bond integrity. In contrast, monolithic zirconia crowns, by eliminating the veneering layer, demonstrated markedly lower complication rates, often below 5%, thereby confirming their superior mechanical reliability. Similar findings were reported by Stawarczyk B et al., who emphasized that monolithic zirconia significantly reduces the risk of catastrophic failure due to its homogeneous structure[13].

From a biomechanical perspective, the superior performance of monolithic zirconia can be explained by its high flexural strength and fracture toughness, typically ranging between 900 and 1200 MPa[20]. This makes it particularly suitable for posterior restorations and patients with high occlusal loads or parafunctional habits. Zhang Y et al. highlighted that transformation toughening in zirconia contributes to crack resistance, thereby enhancing long-term durability[8]. Conversely, layered zirconia restorations, while mechanically adequate, remain more susceptible to cohesive and adhesive failures within the veneering porcelain, especially under cyclic loading conditions.

In terms of marginal adaptation, the present analysis found no statistically significant differences between monolithic and layered zirconia crowns, which aligns with the findings of Nakamura K et al., who reported comparable marginal accuracy for both systems using CAD/CAM fabrication techniques[17]. This suggests that the manufacturing process, rather than the crown design, plays a more critical role in determining marginal integrity. Furthermore, both types of restorations demonstrated favorable biological outcomes, including minimal plaque accumulation and healthy gingival response, confirming the excellent biocompatibility of zirconia as a restorative material[21].

Esthetic considerations remain a key factor influencing material selection. Layered zirconia crowns continue to provide superior optical properties, including translucency and depth of color, which are essential in anterior restorations[26]. However, recent advancements in high-translucency monolithic zirconia have significantly improved their esthetic performance, narrowing the gap between the two systems[5]. Guess PC et al. noted that modern monolithic zirconia materials exhibit enhanced light transmission properties, making them increasingly viable for anterior applications without compromising strength[14].

From a clinical standpoint, these findings underscore the importance of a case-specific approach. Monolithic zirconia crowns are particularly advantageous in posterior regions where mechanical demands are high, whereas layered zirconia remains the material of choice in cases requiring superior esthetics. The decision-making process should therefore integrate functional, biological, and esthetic considerations to optimize long-term treatment outcomes.

V. Conclusion

Within the limitations of this systematic review, it can be concluded that both monolithic and layered zirconia crowns exhibit high clinical survival rates, confirming their reliability as restorative materials in fixed prosthodontics. However, significant differences exist in their complication profiles, with monolithic zirconia demonstrating superior mechanical performance and a markedly lower incidence of chipping and fracture. These findings are in agreement with multiple clinical studies, including those by Pjetursson BE et al., who reported comparable survival but higher technical complications in veneered restorations[9].

Layered zirconia crowns, while offering enhanced esthetic outcomes, remain susceptible to veneering ceramic failures, which may compromise long-term success and increase maintenance requirements. In contrast, the monolithic design eliminates the weak interface, resulting in improved structural integrity and longevity. Importantly, both systems exhibit comparable marginal adaptation and biological behavior, indicating that zirconia, irrespective of design, is a biocompatible and clinically effective material.

Clinical selection should therefore be individualized, with monolithic zirconia preferred for posterior load-bearing restorations and patients with high functional demands, while layered zirconia may be reserved for anterior regions where esthetics are paramount. Future research should focus on long-term randomized clinical

trials exceeding 10 years, as well as the continued development of ultra-translucent zirconia materials that combine optimal esthetics with superior mechanical properties.

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