Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(1), 622-637 | ISSN:2251-6727

Comparative Evaluation of the Effect of Different Finish Lines on Fracture Resistance of Zirconia Crowns: A Systematic Review and Meta-Analysis

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(Received: 16 November 2024 Revised: 20 December 2024 Accepted: 04 January 2025)

KEYWORDS

Zirconia crowns, Finish line, Fracture resistance, Chamfer

ABSTRACT:
The fracture resistance of zirconia crowns is significantly influenced by the finish line design of tooth preparations. This systematic review and meta-analysis aimed to evaluate the impact of various finish lines, including chamfer, deep chamfer, and shoulder designs, on zirconia crown performance. A comprehensive literature search across multiple databases identified 17 in-vitro studies for inclusion. Fracture resistance was assessed using universal testing machines, with chamfer and deep chamfer finish lines demonstrating higher resistance compared to shoulder designs, although the differences were not statistically significant. Meta-analysis revealed a pooled mean difference favoring chamfer finish lines for improved stress distribution and structural integrity. The heterogeneity observed highlights the influence of factors such as preparation geometry, material thickness, and cementation protocols. The findings suggest that chamfer and deep chamfer finish lines offer mechanical advantages for zirconia crowns, but further clinical studies are necessary to establish definitive guidelines for optimal finish line design in prosthodontic practice.

Introduction

The clinical success of prosthodontic restorations is influenced by multiple factors, including material selection, occlusal considerations, luting agents, and tooth preparation design. Among these, the finish line design plays a crucial role in determining the biomechanical performance of the restoration, particularly in high-strength ceramic restorations such as zirconia crowns.[1] Zirconia has gained widespread acceptance in restorative dentistry due to its excellent mechanical properties, biocompatibility, and superior aesthetics compared to conventional porcelain-fused-to-metal (PFM) crowns. However, despite its high strength, zirconia remains susceptible to mechanical failure under occlusal loading, making the choice of an appropriate finish line a significant consideration in clinical practice.[2]

The finish line serves as the interface between the tooth and the restoration, influencing stress distribution, marginal adaptation, and overall structural integrity. Different finish line designs, including chamfer, deep chamfer, shoulder, sloped shoulder, and knife-edge, have been proposed to optimize zirconia crown performance.[1] The chamfer and deep chamfer designs are often preferred for their ability to facilitate smooth stress distribution and ease of preparation, whereas the shoulder finish line provides a broader and more stable seating area, reducing marginal discrepancies. Conversely, knife-edge and beveled designs, though minimally invasive, may lead to reduced bulk at the restoration margin, increasing the risk of chipping and fracture.

The fracture resistance of zirconia crowns is a critical determinant of their long-term clinical success, as mechanical failure can lead to costly and complex retreatment.[2] Several in vitro studies have attempted to evaluate the impact of different finish line designs on fracture resistance, but the results have been inconsistent.[1,3,4] Some studies suggest that chamfer and deep chamfer finish lines enhance fracture resistance by reducing stress concentration at the margins, while

others indicate that shoulder finish lines offer better support for zirconia crowns due to their ability to maintain adequate material thickness at the cervical area. These conflicting findings necessitate a systematic synthesis of available evidence to guide clinical decision-making.

Furthermore, the interaction between finish line design and other factors such as occlusal loading, cementation protocols, and aging-related degradation of zirconia remains an area of active investigation.[2] The presence of microcracks, phase transformation phenomena in zirconia (t→m transformation), and fatigue loading conditions in the oral cavity may further influence the effectiveness of various finish line designs.

Given these considerations, this systematic review and meta-analysis aim to evaluate the effect of different finish line designs on the fracture resistance of zirconia crowns by synthesizing findings from existing literature. The objective is to identify an optimal finish line configuration that maximizes the mechanical durability of zirconia restorations, thereby contributing to evidence-based recommendations for clinical practice.

Methods

Protocol and Registration

The present systematic review sought to answer the research questions ‘Is there any difference in the effect of different finish lines on fracture resistance of Zirconia crowns?’ and ‘Which finish line provides maximum fracture resistance to zirconia crowns?’ The review was conducted according to the Preferred Reporting Items for Systematic Review (PRISMA 2020) guidelines and the Cochrane Handbook for Systematic Reviews of Interventions, version 5.1.0. The review protocol was registered at PROSPERO under registration code CRD42024561446.

Search strategy

The electronic data resources consulted for elaborate search were Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, CINAHL, EMBASE, PsycINFO, Scopus, ERIC, ScienceDirect with controlled vocabulary and free text terms. (Table 1) Articles published until 30/07/2024 were searched, without any restriction concerning the publication’s language. The keywords and MeSH terms were used in combination with Boolean operators in the advanced search option are denoted in Table 1.

Table 1: Keywords used in performing the search in the present systematic review

Population	**Intervention and Comparison**	**Outcome**	**Study design**
Maxillary teeth Mandibular teeth Teeth replica Zirconia coping Zirconia crown	Finish line Chamfer Deep chamfer Shoulder Sloped shoulder	Fracture resistance	Invitro study Experimental study Clinical trial Randomized clinical Trials and cross-sectional studies

Search using PubMed search engine

((permanent teeth OR teeth replica OR teeth dies OR zirconia crown) AND (crown preparation AND finish line AND chamfer OR deep chamfer OR shoulder OR sloped shoulder)) AND (fracture resistance OR fracture load)

The comprehensive strategy is shown in Table 2.

Table 2: Search Strategy in PubMed Central (PMC)/MEDLINE according to PICO

Population	(((("maxilla"[MeSH Terms] OR "maxilla"[All Fields] OR "maxillary"[All Fields]) AND ("tooth"[MeSH Terms] OR "tooth"[All Fields] OR "teeth"[All Fields])) OR (("mandible"[MeSH Terms] OR "mandible"[All Fields] OR "mandibular"[All Fields]) AND ("tooth"[MeSH Terms] OR "tooth"[All Fields] OR "teeth"[All Fields]))) OR (("tooth"[MeSH Terms] OR "tooth"[All Fields]) AND replica[All Fields])) AND ((("zirconium oxide"[Supplementary Concept] OR "zirconium oxide"[All Fields] OR "zirconia"[All Fields]) AND ("crowns"[MeSH Terms] OR "crowns"[All Fields])) OR (("zirconium oxide"[Supplementary Concept] OR "zirconium

	oxide"[All Fields] OR "zirconia"[All Fields]) AND copings[All Fields]))
Intervention and Comparison	((((finish[All Fields] AND line[All Fields] AND preparation[All Fields]) AND chamfer[All Fields]) OR (heavy[All Fields] AND chamfer[All Fields])) OR ("shoulder"[MeSH Terms] OR "shoulder"[All Fields])) OR feather-edged[All Fields]
Outcome	"fracture"[All Fields]) AND resistance[All Fields] AND ("zirconium oxide"[Supplementary Concept] OR "zirconium oxide"[All Fields] OR "zirconia"[All Fields])

Selection of Studies

Studies were selected based on the PICOS inclusion criteria in the review protocol (Table 3). Two reviewers assessed titles and abstracts to identify potentially eligible studies. Any queries were discussed with a third reviewer. The selection process involved a thorough screening of the titles and abstracts of all identified records, conducted independently by two reviewers. If an abstract lacked sufficient information to determine eligibility, the full-text version of the article was retrieved for further assessment. Each study was carefully evaluated against the predefined inclusion and exclusion criteria to ensure its relevance to the review. Any disagreements between the two reviewers were resolved through discussion, and in cases where consensus could not be reached, a third reviewer was consulted to make the final decision. Studies that did not meet the eligibility criteria were excluded, and the reasons for their exclusion were systematically documented in the characteristics of excluded studies table.

Table 3: PICOS framework for the selection of articles in the present systematic review

Category	Inclusion Criteria	Exclusion Criteria
Population	Studies including caries-free maxillary or mandibular teeth or tooth replica (dies) made of materials such as acrylic, stainless steel, etc.	Studies not fully available in the database.
Intervention	Studies including human teeth or dies prepared with different finish lines such as Chamfer, Deep Chamfer, Shoulder, Sloped Shoulder, etc.	Single group studies without a control group.
Comparison	Different finish lines compared with each other.	Review reports, case series, and animal studies.
Outcome	Studies providing information about fracture resistance of zirconia crowns.	Studies providing only abstracts without full text.
Study Design	Studies published in any language with available English translation; studies published till 30-07-2024; clinical trials, in-vivo studies, randomized clinical trials, controlled clinical trials, non-randomized clinical trials, quasi-experimental studies, non-experimental studies, cohort studies, cross-sectional studies, and in-vitro studies; full-text articles included.	Studies not mentioning required outcomes.

Data Extraction and Management

Data extraction was conducted systematically using a structured data extraction form designed to capture critical details from each included study. Two independent reviewers extracted data to minimize bias and ensure accuracy. In cases where discrepancies arose, a third reviewer was consulted for resolution. If any essential information was missing or unclear, the authors of the original studies were contacted for clarification or additional details. The extracted data included study identification details, geographical location, study design and methodology, sample size,

characteristics of the sample used, type of zirconia crowns evaluated, finish line configurations under investigation, primary outcomes assessed, methods used for measuring outcomes, statistical analyses applied, and main conclusions. All extracted information was compiled in a structured format to facilitate systematic comparison and analysis.

Risk of Bias Assessment

The methodological quality of the included studies was assessed using the QUIN (Quality Index for In Vitro Studies) tool. This assessment considered multiple aspects, including clarity of study objectives, sample size calculation, sampling technique, presence of a control group, detailed description of the methodology, operator experience, randomization procedures, blinding, outcome measurement methods, statistical analyses, and presentation of results. Each study was categorized as having a low, medium, or high risk of bias based on predefined scoring criteria. Studies were assigned a numerical score based on whether key methodological aspects were adequately reported. The final score was used to classify studies into one of three risk levels: high risk if the score was below 50%, medium risk if the score ranged from 50% to 70%, and low risk if the score exceeded 70%. The risk of bias assessment helped determine the reliability of the findings synthesized from the included studies.

Measures of Treatment Effect

The impact of different interventions on fracture resistance was evaluated using appropriate statistical measures. For dichotomous outcomes, the effect size was expressed as a risk ratio with a 95% confidence interval. For continuous variables, mean values and standard deviations were used to summarize the data for each study group. These measures allowed for a standardized comparison of the effects of different finish line designs on zirconia crown performance.

Assessment of Heterogeneity

Heterogeneity among the included studies was assessed to determine the extent of variability in the reported outcomes. Clinical heterogeneity was examined by comparing differences in the study populations, interventions, and outcome measures. Statistical heterogeneity was quantified using Cochran’s Q test and the I^2 statistic, which estimates the proportion of total variation attributed to heterogeneity rather than random chance. The I^2 statistic was interpreted based on Cochrane Handbook guidelines: values below 30% indicated minimal heterogeneity, 30% to 60% represented moderate heterogeneity, 50% to 90% indicated substantial heterogeneity, and values above 75% suggested considerable heterogeneity. If significant heterogeneity was detected, further exploration was conducted to identify potential sources of variation across studies.

Data Synthesis

A meta-analysis was conducted if multiple studies reported comparable outcomes. The inverse variance method was used for pooling data, applying either a fixed-effects model or a random-effects model based on the level of heterogeneity. When heterogeneity was low, a fixed-effects model was used, whereas a random-effects model was preferred if substantial heterogeneity was present. The effect sizes for dichotomous outcomes were reported as risk ratios, while continuous outcomes were analyzed using mean differences or standardized mean differences. Meta-analysis was only performed when sufficient studies provided data on the same outcome measure.

Results

Study selection

The initial electronic database search on PubMed (n=52), PMC/MEDLINE (n=395), Cochrane Library (n=403), and DOAJ (n=105) resulted in 955 titles. 696 articles were cited as duplicates. After screening the abstracts, 152 relevant titles were selected by two independent reviewers were sought for retrieval and 107 were excluded for not being related to the topic. Following examination and discussion by the reviewers, 30 articles were selected for full-text evaluation. Hand searching of the reference lists of the selected studies did not deliver additional papers. After pre-screening, application of the inclusion and exclusion criteria and handling of the PICO questions, 17 studies remained. A total of 17 studies were included in the qualitative synthesis which were subjected to data extraction and statistical analysis. **(Figure 1)**

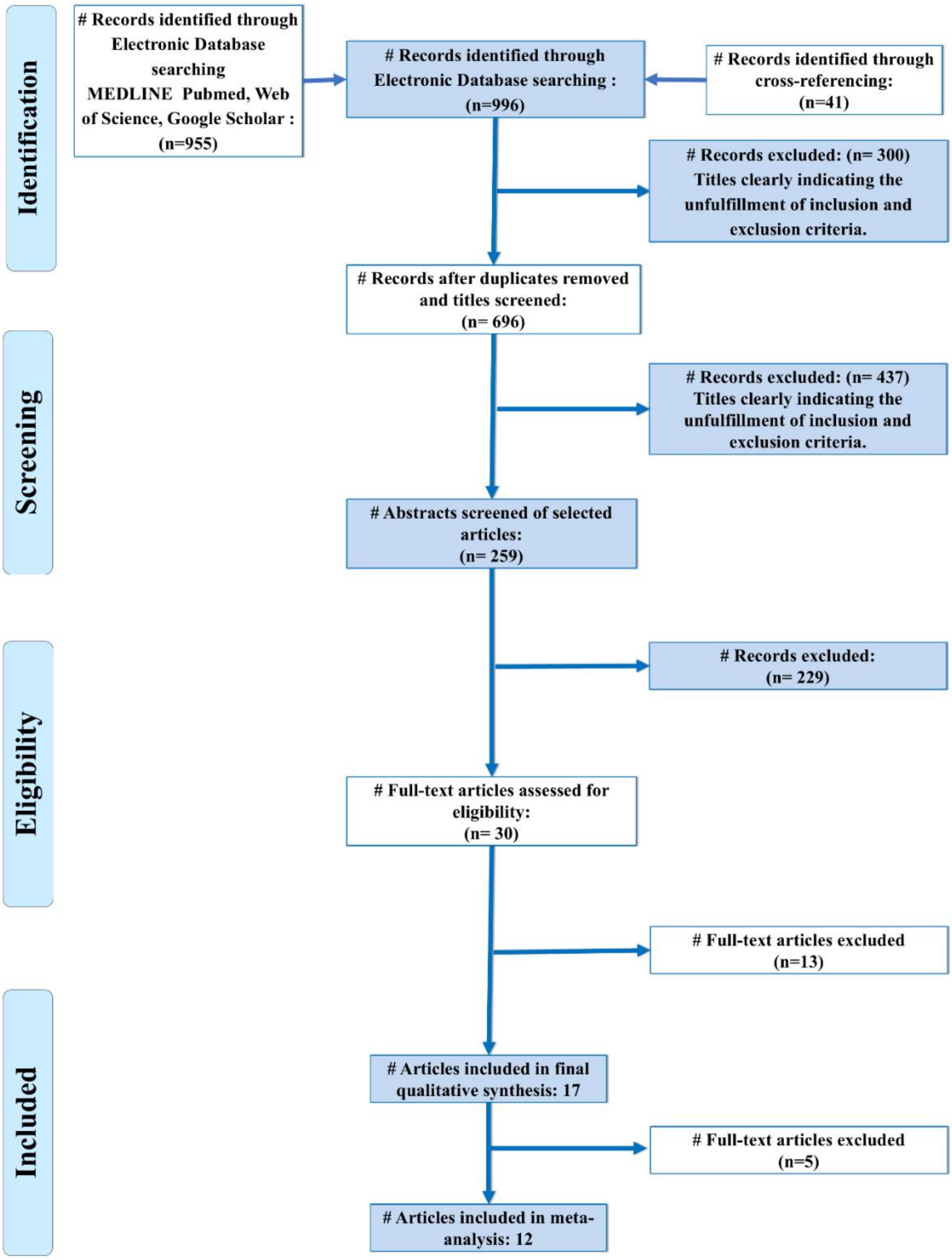


Figure 1: PRISMA 2020 flow diagram

Study characteristics

Seventeen studies were included in this systematic review whose general characteristics are presented in Table 4. All the included studies showed invitro study design. These studies were conducted in different parts of world – Germany[5], Iran[6,7,9,11,15] Egypt[8,19], Baghdad[10], Austria[12], Egypt[13], Saudi Arabia[14], Iraq[16], Norway[17], India[20,21]. A majority of studies were conducted in Iran.

Table 4: Data extracted from the studies included in the present systematic review

Sr. No.	**Study ID**	**Place of study**	**Ethical approval**	**Study design**	**Sample size**	**Sample used**	**Teeth used**	**Crown material**	**cementation of crown**	**Outcomes assessed**	**method used for outcome assessment**
1	**Beuer 2007**	Germany	not mentioned	invitro	50	acrylic teeth	maxillary right molars	Hot isostatic pressed (HIP) zirconia	GIC	fracture load	universal testing machine (Type 1445, Zwick, Ulm, Germany)
2	**Jalalian and Atashkar 2011**	Iran	not mentioned	invitro	20	stainless steel die	NA	sintered ZrO2 copings (Cercon Smart Ceramics, Degu Dent, Hanau, Germany)	GIC	fracture resistance	universal testing machine (GOTECH AI 700LAC, Arsona, USA).
3	**Jalalian and Rostami 2011**	Iran	not mentioned	invitro	20	epoxy resin dies	NA	sintered ZrO2 copings (Cercon Smart Ceramics, Degu Dent, Hanau, Germany)	GI (GC Gold Labled, Tokyo, Japan)	fracture resistance	universal testing machine (GOTECH AI-700LAC, Arsona, USA).

4	**Aboushelib 2011**	Egypt	not mentioned	invitro	45	not mentioned	maxillary central incisor	CAD/CAM zirconia blocks (Cercon)	adhesive resin cement	fracture resistance	universal testing machine (Instron 6022; Instron Limited
5	**Ahmadzadeh 2015**	Iran	not mentioned	invitro	40	epoxy resin dies	maxillary first premolar	IPS e.max crowns - Zir CAD core, Press core	Panavia F21 resin cement.	fracture resistance	universal testing machine (Gotech AI, 700LAC, Arizona, USA)
6	**Al-Jouboury 2015**	Baghdad	not mentioned	invitro	16	human teeth	maxillary first premolars	zirconia full contour CAD/CAM crowns (zolid, Ceramill Systems)	self-adhesive dual-cure resin cement	fracture resistance	universal testing machine (Tinius Olsen H50KT)
7	**Jalali 2015**	Iran	yes	invitro	24	human teeth	mandibular premolars	Zirconia (Cercon Base, Cercon, Degu Dent, Hanau, Germany)	-	fracture load	universal testing machine (Zwick Roell Z050, Ulm, Germany)
8	**Mitov 2015**	Austria	not mentioned	invitro	30	acrylic teeth	maxillary molars	monolithic zirconia crowns	not mentioned	fracture resistance	universal testing machine

9	**Haggag 2017**	Egypt	not mentioned	invitro	40	metal dies	NA	monolithic zirconia crowns		fracture resistance	universal testing machine (Tinius Olsen H50KT)
10	**Alzahrani 2018**	Saudi Arabia	Not mentioned	invitro	20	acrylic teeth	maxillary first premolars	CAD/ CAM monolithic zirconia		fracture resistance	Universal testing machine
11	**Ardakani 2019**	Iran	not mentioned	invitro	20	brass dies	NA	zirconia copings	glass-ionomer luting cement	fracture resistance	Universal Testing Machine (Zwick 20; Zwick/ Roll, Germany)
12	**Findakly 2019**	iraq	not mentioned	invitro	40	human teeth	maxillary first premolars	A. monolithic traditional zirconia B. monolithic translucent zirconia	resin cement	fracture resistance	computer-controlled universal testing machine
13	**Skjold 2019**	Norway	not mentioned	invitro	90	artificial models	premolar	zirconia	zinc phosphate oxide cement	fracture load	-
14	**Jasim 2020**	Iraq	not mentioned	invitro	40	human teeth	maxillary first premolar teeth	zirconia copings	self-adhesive resin cement	fracture resistance	(universal testing machine; Laryee Technology, Beijing, China)

15	**Emam 2021**	Egypt	not mentioned	invitro	40	epoxy resin dies	NA	zirconia copings	GIC, self adhesive dual cured resin cement	fracture resistance	Universal testing machine
16	**Singh 2022**	India	not mentioned	invitro	48	typhodont tooth	premolar	monolithic zirconia crown	Resin based Adhesive system	fracture resistance	quasi-static load test in UTM (Universal Testing Machine)
17	**Gavara 2023**	India	not mentioned	10 each group	10	human teeth	first maxillary premolars	zirconia (Cercon HT disc)	GIC luting cement	fracture resistance	

A total of 593 teeth were included in this review of which three studies[5,12,14] used acrylic teeth, one study[6] used stainless steel dies, epoxy resin dies used by three studies[7,9,19], five used human teeth[10,11,16,18,21], one used metal dies[13] and one study used brass dies[15]. Different finish line preparations were included in the studies – chamfer, deep chamfer, shoulder, radial shoulder, etc. For cementation of the zirconia crowns, GIC and resin cement were commonly used. Fracture resistance of zirconia was the outcome assessed in this review. Universal testing machine was used for the assessment of fracture resistance of the zirconia crowns.

Risk of bias assessment

Among the included studies, three showed a low risk of bias and fourteen studies showed a moderate risk of bias. Consequently, all the articles included in this review met or exceeded 50% of the assessed criteria. The details of the risk of bias assessment are provided in Table 5.

Table 5: Risk of bias assessment

Study ID	**Clearly stated aim, objectives**	**Detailed explanation of**	**Detailed explanation of sampling**	**Details of comparison group**	**Detailed explanation of methodology**	**Operator details**	**Randomization**	**Method of outcom**	**Outcome assessment details**	**Blinding**	**Statistical analysis**	**Presentation of results**	**Score**	**%**	**Risk of bias**

		sample size calculation	**technique**					**e measurement**							
Beuer 2007	2	0	0	2	2	0	0	2	2	0	2	2	14	5833	Medium
Jalalian and Atashkar 2011	2	0	0	2	2	0	0	2	2	0	2	2	14	5833	Medium
Jalalian and Rostami 2011	2	0	0	2	2	0	0	2	2	0	2	2	14	5833	Medium
Aboushelib 2011	2	0	0	2	2	1	0	2	2	0	2	2	15	6250	Medium
Ahmadzadeh 2015	2	0	0	2	2	1	0	2	2	0	2	2	15	6250	Medium
Al-Joboury 2015	2	0	0	2	2	2	2	2	2	0	2	2	18	750	Low
Jalali 2015	2	0	0	2	2	2	2	2	2	0	2	2	18	750	Low
Mitov 2015	2	0	0	2	2	0	0	2	2	0	2	2	14	5833	Medium
Haggag 2017	2	0	0	2	2	0	0	2	2	0	2	2	14	5833	Medium
Alzahrani 2018	2	0	0	2	2	0	0	2	2	0	2	2	14	5833	Medium
Ardakani 2019	2	0	0	2	2	1	0	2	2	0	2	2	15	6250	Medium
Findakly 2019	2	0	0	2	2	2	2	2	2	0	2	2	18	750	Low
Skjold 2019	2	0	0	2	2	1	0	2	2	0	2	2	15	6250	Medium
Jasim	2	0	0	2	2	0	0	2	2	0	2	2	14	58	Med

2020													33	ium
Emam 2021	2	0	0	2	2	1	0	2	2	0	2	2	15	6250	Medium
Singh 2022	2	0	0	2	2	2	0	2	2	0	2	2	16	6667	Medium
Gavara 2023	2	0	0	2	2	0	0	2	2	0	2	2	14	5833	Medium

Meta-analysis

Data synthesis was carried out using a descriptive synthesis, with a summary of the characteristics of each included study. For quantitative synthesis, a summary of the combined estimate related to the intervention effect was calculated as a mean of the differences of the effects of post-intervention in individual studies (Table 6). Out of the 17 studies, n=12 were included in the meta-analysis.

Table 6: Data related to finish lines which was subjected to meta-analysis

Study ID	**Sample size**	**Finish lines**	**depth of the finish line**	**Fracture resistance**
Beuer 2007	50	shoulderless	0.5 mm	2041+-355
		slight chamfer	0.5mm	1624+-150
		deep chamfer	1mm	1752+-261
		shoulder	1mm	2286+-536
		shoulder with bevel	1mm	1722+-262
Jalalian and Atashkar 2011	20	chamfer	0.8 mm	991.75+-112
		shoulder	1 mm	788.9+-99.56
Jalalian and Rostami 2011	20	chamfer	0.8 mm	991.75+-112.01
		deep chamfer	1 mm	1426.1+-182.606
Ahmadzadeh 2015	40	chamfer	0.8 mm	Zircad core:1426+-335.16 Press core: 1059.9+-113.96
		shoulder	1 mm	Zircad core:1361.3+-386.76 Press core: 1295.8+-413.26
Al-Joboury 2015	16	deep chamfer	1 mm	1109.25+-252.45
		90 degree shoulder	1.2 mm	1367.25+-178.96

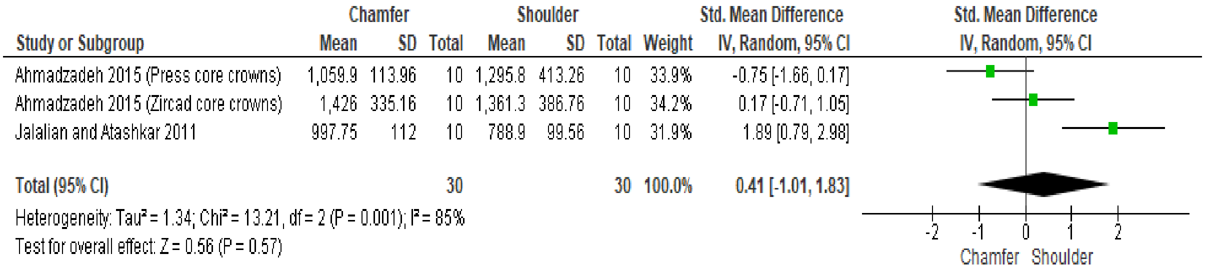
Mitov 2015	30	Shoulderless		5712+-758
		Slight chamfer	0.4 mm	4703+-787
		Chamfer	0.8 mm	5090+-741
Alzahrani 2018	20	deep chamfer	1 mm	3070.72+-415.18
		shoulder	1.3 mm	2287.57+-144.49
Ardakani 2019	20	90 degree shoulder	-	368.3+-109.4
		135 degree shoulder		518.4+-115.5
Findakly 2019	40	1. shoulder 2. feather-edged		A1: 2.903+-0.22 A2: 2.3+-0.251
		1. shoulder 2. feather-edged		B1:1.854+-0.195 B2:1.523+-0.21
Emam 2021	40	knife edge		987.04+-94.18
		chamfer	0.5 mm	883.28+-205.42
		deep chamfer	1 mm	767.66+-207.09
		shoulder	1 mm	828.64+-227.79
Singh 2022	48	radial shoulder	1.1mm 0.5mm 0.8mm	1. 1834.8+-253.3 2.1544.25+-516.1 3.1449.3+-147.58
		Chamfer	1.1mm 0.5mm 0.8mm	1.222.013+-376.67 2. 1272.38+-214.46 3. 1325.38+-227.48
Gavara 2023	10	heavy chamfer	< 0.3mm	451.00+-90.26
		shoulder	0.3 mm	353.8+-64.33

Shoulder vs chamfer/deep chamfer finish line

Eight studies[5,6,9,10,14,19-21] compared the fracture resistance of zirconia crowns with shoulder and chamfer finish lines. Four of these studies [6,14,20,21] stated that chamfer and deep chamfer finish lines improve the fracture resistance of zirconia crowns as compared to shoulder finish lines, while one study by Al-Jouboury et al. showed that both shoulder and chamfer finish lines are suitable.

Chamfer vs shoulder finish line

Two studies were included in the assessment of fracture resistance of zirconia crowns with chamfer and shoulder finish line (Figure 2). A total of 30 teeth samples were assessed. The pooled fracture resistance obtained was 0.41[-1.01, 1.83] indicating that the fracture resistance was greater with the chamfer finish line as compared to shoulder, however, the difference was not statistically significant (p>0.05). As heterogeneity was more than 50% (I2=85%), the random effects model was used for assessment.

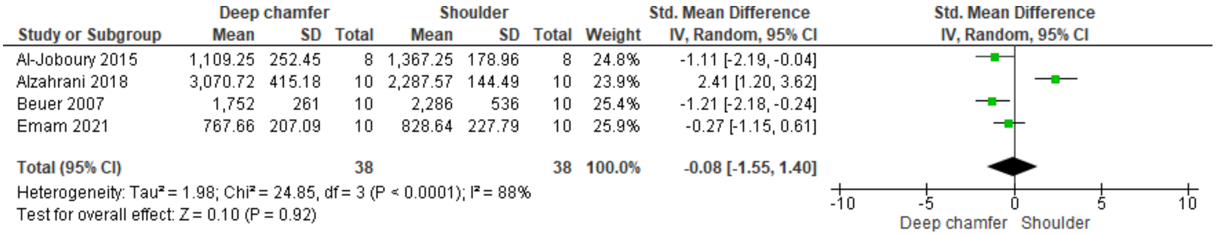


Study or Subgroup	Chamfer Mean	Chamfer SD	Chamfer Total	Shoulder Mean	Shoulder SD	Shoulder Total	Weight	Std. Mean Difference IV, Random, 95% CI
Ahmadzadeh 2015 (Press core crowns)	1,059.9	113.96	10	1,295.8	413.26	10	33.9%	-0.75 [-1.66, 0.17]
Ahmadzadeh 2015 (Zircad core crowns)	1,426	335.16	10	1,361.3	386.76	10	34.2%	0.17 [-0.71, 1.05]
Jalalian and Atashkar 2011	997.75	112	10	788.9	99.56	10	31.9%	1.89 [0.79, 2.98]
Total (95% CI)			**30**			**30**	**100.0%**	**0.41 [-1.01, 1.83]**

Heterogeneity: Tau^2 = 1.34; Chi^2 = 13.21, df = 2 (P = 0.001); I^2 = 85%
Test for overall effect: Z = 0.56 (P = 0.57)

Deep chamfer vs shoulder

Four studies were included in the assessment of fracture resistance of zirconia crowns with deep chamfer and shoulder finish line (Figure 3). A total of 38 teeth samples were assessed. The pooled fracture resistance obtained was -0.08[-1.55, 1.40] indicating that the fracture resistance was slightly greater with the shoulder finish line as compared to deep chamfer, however, the difference was not statistically significant (p>0.05). As heterogeneity was more than 50% (I2=85%), random effects model was used for assessment.



Study or Subgroup	Deep chamfer Mean	Deep chamfer SD	Deep chamfer Total	Shoulder Mean	Shoulder SD	Shoulder Total	Weight	Std. Mean Difference IV, Random, 95% CI
Al-Jobourу 2015	1,109.25	252.45	8	1,367.25	178.96	8	24.8%	-1.11 [-2.19, -0.04]
Alzahrani 2018	3,070.72	415.18	10	2,287.57	144.49	10	23.9%	2.41 [1.20, 3.62]
Beuer 2007	1,752	261	10	2,286	536	10	25.4%	-1.21 [-2.18, -0.24]
Emam 2021	767.66	207.09	10	828.64	227.79	10	25.9%	-0.27 [-1.15, 0.61]
Total (95% CI)			**38**			**38**	**100.0%**	**-0.08 [-1.55, 1.40]**

Heterogeneity: Tau^2 = 1.98; Chi^2 = 24.85, df = 3 (P < 0.0001); I^2 = 88%
Test for overall effect: Z = 0.10 (P = 0.92)

Discussion

The choice of finish line design is a crucial factor influencing the long-term success of zirconia crowns, affecting fracture resistance, marginal adaptation, and biomechanical stability. This systematic review and meta-analysis assessed the comparative effects of different finish lines, including chamfer, deep chamfer, shoulder, and sloped shoulder, on the fracture resistance of zirconia crowns. The findings suggest that variations in finish line design significantly impact mechanical performance, with differences observed across studies. Beuer et al. (2007) reported that the shoulder finish line provided superior structural stability, whereas Jalalian and Atashkar (2011) found that chamfer and deep chamfer designs enhanced fracture resistance by reducing stress concentration. The variability in findings highlights the importance of considering multiple clinical factors when selecting a finish line for zirconia restorations.

Fracture resistance is a critical determinant of zirconia crown longevity, as failure due to mechanical breakdown necessitates replacement and additional interventions. Studies by Aboushelib et al. (2011) and Jalalian and Rostami (2011) indicated that shoulder finish lines facilitate uniform stress distribution, minimizing the risk of chipping or catastrophic fracture. In contrast, Ahmadzadeh et al. (2015) observed that deep chamfer finish lines provided superior load-bearing capacity, possibly due to their ability to maintain a gradual stress transition at the crown margins. Al-Joboury et al. (2015) supported these findings, demonstrating that both shoulder and chamfer

finish lines performed well under occlusal loading, with no statistically significant difference in failure rates. However, Mitov et al. (2015) noted that knife-edge and bevel finish lines resulted in lower fracture resistance, likely due to inadequate bulk thickness at the marginal area, leading to increased stress concentrations and early failure.

Differences in fracture resistance outcomes may be attributed to variations in material thickness, preparation geometry, and occlusal loading conditions across studies. Zirconia is known for its high compressive strength, but it remains susceptible to crack propagation under tensile stresses. Haggag et al. (2017) and Alzahrani et al. (2018) reported that sharper angles or inadequate material bulk at the finish line could serve as initiation points for crack development, ultimately reducing the restoration's longevity. Ardakani et al. (2019) emphasized that the radial shoulder design provided a balance between marginal integrity and mechanical stability, making it a viable alternative to traditional shoulder preparations. The role of cementation protocols was also highlighted by Findakly et al. (2019), who found that resin-based cements provided superior reinforcement at the tooth-restoration interface compared to glass ionomer cement, further enhancing fracture resistance.

The influence of artificial aging and testing conditions must also be considered when interpreting the findings of in-vitro studies. Skjold et al. (2019) and Jasim et al. (2020) noted that thermocycling and cyclic loading significantly impact zirconia crown performance by simulating intraoral stress conditions. Emam et al. (2021) demonstrated that deep chamfer finish lines retained their mechanical properties even after extensive thermomechanical aging, suggesting their long-term reliability in clinical applications. Singh et al. (2022) reinforced these findings, reporting that chamfer finish lines demonstrated consistent fracture resistance across various loading conditions, making them a preferred choice for zirconia restorations subjected to high occlusal forces. Gavara et al. (2023) further emphasized the importance of finish line precision, as discrepancies in preparation geometry could lead to variations in stress distribution and ultimately affect clinical outcomes.

The findings of this review have important clinical implications, as the selection of an appropriate finish line design should be guided by the interplay of multiple factors, including occlusal forces, esthetic demands, and patient-specific functional considerations. While deep chamfer and chamfer finish lines appear to offer optimal stress distribution, the shoulder finish line remains a viable option for cases requiring enhanced marginal adaptation. Additionally, digital workflows and CAD/CAM fabrication techniques have improved the precision of finish line preparation, reducing the risk of stress-induced failures. However, despite these advancements, the current body of evidence is largely derived from in-vitro studies, necessitating further clinical research to validate these findings under real-world conditions.

This systematic review highlights the need for long-term clinical studies evaluating the impact of different finish line designs on zirconia crown survival rates in diverse patient populations. Standardized testing protocols should be established to ensure comparability across studies, particularly regarding fracture resistance assessment and artificial aging methodologies. Finite element analysis (FEA) may provide additional insights into stress distribution patterns associated with various finish lines, aiding in the development of optimized preparation guidelines. Moreover, emerging zirconia materials with improved translucency and fracture toughness warrant further investigation to determine whether traditional finish line recommendations remain applicable.

Conclusion:

The evidence analyzed in the review suggests that chamfer and deep chamfer finish lines may offer superior biomechanical advantages for zirconia crowns, primarily due to their ability to minimize stress concentrations while preserving tooth structure. Shoulder finish lines, while effective in ensuring marginal integrity, may be associated with higher localized stress at the restoration interface. Clinicians should consider individual patient factors, including occlusal loading conditions, parafunctional habits, and esthetic requirements, when selecting the appropriate finish line design. Further research, particularly well-designed clinical trials, is needed to establish definitive guidelines for optimizing the long-term performance of zirconia restorations.

References

1. Aboushelib MN. Fatigue and fracture resistance of zirconia crowns prepared with different finish line designs. Journal of Prosthodontics: Implant, Esthetic and Reconstructive Dentistry. 2012 Jan;21(1):22-7.
2. Alghazzawi TF, Janowski GM, Eberhardt AW. An experimental study of flexural strength and hardness of zirconia and their relation to crown failure loads. The Journal of prosthetic dentistry. 2024 Feb 1;131(2):320-8.
3. Beuer F, Aggstaller H, Edelhoff D, Gernet W. Effect of preparation design on the fracture resistance of zirconia crown copings. Dental materials journal. 2008;27(3):362-7.
4. Alzahrani AM, Beyari AM, Emam ZN. The influence of the cervical finish line designs on the fracture resistance of CAD/CAM monolithic zirconia crowns: An in vitro study. Int. J. Health Sci. Res. 2018;8:101-10.
5. Beuer F, Aggstaller H, Edelhoff D, Gernet W. Effect of preparation design on the fracture resistance of zirconia crown copings. Dent Mater J. 2008;27(3):362–7.
6. Jalalian E, Atashkar B, Rostami R. The effect of preparation design on the fracture resistance of zirconia crown copings (computer associated design/computer associated machine, CAD/CAM system). J Dent (Tehran) [Internet]. 2011;8(3):123–9.
7. Jalalian E, Rostami R, Atashkar B. Comparison of chamfer and deep chamfer preparation designs on the fracture resistance of zirconia core restorations. J Dent Res Dent Clin Dent Prospects [Internet]. 2011;5(2):41–5.
8. Aboushelib MN. Fatigue and Fracture Resistance of Zirconia Crowns Prepared with Different Finish Line Designs. J Prosthodont. 2012;21(1):22–7.
9. Ahmadzadeh A, Golmohammadi F, Mousavi N. Effect of Marginal Design on Fracture Resistance of IPS e . max all Ceramic Restorations : Chamfer Versus Shoulder Finish Lines. J Islam Dent Assoc IRAN. 2015;27(2):64–9.
10. Ibrahim A, Al-Joboury K, Ma'an, Zakaria R. March 2015 An evaluation of Restorative Dentistry 54. J Bagh Coll Dent. 2015;27(1):54–62.
11. Jalali H, Sadighpour L, Miri A, Shamshiri AR. Comparison of Marginal Fit and Fracture Strength of a CAD/CAM Zirconia Crown with Two Preparation Designs. J Dent (Tehran) [Internet]. 2015;12(12):874–81.
12. Mitov G, Anastassova-Yoshida Y, Nothdurft FP, Von See C, Pospiech P. Influence of the preparation design and artificial aging on the fracture resistance of monolithic zirconia crowns. J Adv Prosthodont. 2016;8(1):30–6.
13. Haggag K, Hosny M, Abbas M, Ramadan H. Effect of Finish Line Design and Thermo-Mechanical Aging on the Fracture Resistance of Two Types of Monolithic Zirconia Crowns. Egypt Dent J. 2017;63(4):3947–53.
14. Alzahrani AM, Beyari AM, Emam ZN. The influence of the cervical finish line designs on the fracture resistance of CAD/CAM monolithic zirconia crowns: An in vitro study. Int. J. Health Sci. Res. 2018;8:101-10.
15. Hashemi Ardakani Z, Khorsandipour S, Mohaghegh M, Ahmad Ghoreishian S, Khaledi AAR. The Effect of Finish Line Design on the Fracture Strength of Zirconia Copings. J Dent (Shiraz, Iran) [Internet]. 2019;20(4):271–5.
16. Findakly MB, Jasim HH. Influence of preparation design on fracture resistance of different monolithic zirconia crowns: A comparative study. J Adv Prosthodont. 2019;11(6):324–30.
17. Skjold A, Schriwer C, Øilo M. Effect of margin design on fracture load of zirconia crowns. Eur J Oral Sci. 2019;127(1):89–96.
18. Jasim HH, Findakly MB, Mahdi NA, Mutar MT. Effect of Reduced Occlusal Thickness with Two Margin Designs on Fracture Resistance of Monolithic Zirconia Crowns. Eur J Dent. 2020;14(2):245–9.

19. Emam M, El-Etreby A, Younis JF. Fracture resistance and strain analysis of zirconia copings with vertical knife edge and three horizontal finish line designs; chamfer, deep chamfer and shoulder with two cementation techniques. Brazilian Dent Sci. 2021;24(4).

20. Singh K, Singh PS, Malhotra P. Fracture Strength of Thin Monolithic Zirconia Crowns with Varying Thickness and Configuration of Finish LinesAn In Vitro Study. Cardiometry. 2023;(25):1311–8.

21. Gavara SG, Jain S, Gupta H, Sharma S, Panwar P, Momin MS. Comparative Effect of No Finish Line, Heavy Chamfer, and Shoulder Marginal Designs on the Fracture Resistance of Zirconia (Cercon) Ceramic Restoration: An In Vitro Study. Cureus. 2023;15(5).