Clinical performance of alloys and metal ceramic restorations

Asbjørn Jokstad

How many reports with focus on clinical performance of alloys and metal ceramic restorations can be identified?
How many reports related to the topic can be identified?

How are these approx. 877 reports characterized on the basis of their study design?
Strength of evidence
Clinical performance of alloys and metal ceramic restorations

1: Systematic reviews
2: Clinical evidence
3: Laboratory experiments
4: Opinions, descriptive studies, narrative reports, etc.

877

N.B

AIM:
Determine longevity of different dental restoration materials & address cost-effectiveness
### Challenges with studies investigating longevity of dental restorations — a critique of a systematic review

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#### Abstract

A systematic review is critical in evaluating the published and unpublished literature relating to a specific area or topic. The objective of this paper was to critically and systematically examine the limitations in synthesising the available literature and to make recommendations for the future analysis and reporting of clinical trials to ensure a suitable and objective analysis of the evidence. The authors were involved in a large number of studies. The results are expected to have a number of implications for future clinical practice and future methodological studies.

The decision to include a study was based on the authors' expertise and clinical experience. However, the results of this study should be interpreted with caution due to the limitations in the methodology and the potential for selection bias.

- The study included a total of 14000 papers, which were further reduced to 5675 studies.
- Of these, 352 studies were included in the meta-analysis, and 253 studies were included in the qualitative analysis.
- The study was conducted by the authors, who are experienced in the field of dental restorations.

#### Keywords

- Longevity of dental restorations
- Systematic review
- Meta-analysis
- Qualitative analysis

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**Quality of dental restorations**

**FR1 Commission Project C95**

**AIM:** Review all factors that may affect the quality of a dental restoration.

**298 references**

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**Int Dent J 2001; 51: 117-158**

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Clinical studies
1. Observational
2. Experimental
   1. Controlled trials
   2. Prognosis
Clinical studies

1. Observational
   - Replaced restorations (Retrospective)
   - Restorations in situ (Retrospective)

Age of replaced restorations

<table>
<thead>
<tr>
<th>Authors</th>
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<tr>
<td>Mjör et al.</td>
<td>2000</td>
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<td>Mjör &amp; Moorhead</td>
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Clinical studies

1. Observational
   • Replaced restorations (Retrospective)
   • Restorations in situ (Retrospective)

How old are these restorations?

The age of restorations in situ.

Walstrom A, Milger K, Østerg V.

Dental Faculty, University of Oslo, Norway

In a cross-sectional survey, the age of restorations in situ were recorded in three patient groups. Group A were randomly selected regular attenders, group B was regular attenders randomly chosen from patient treatment records, and group C an age-matched gold and composite class II restoration were selected for selected regular attenders. The study material included 341 restorations. In group A, 131 were in group B, and 96 restorations in group C. The teeth materials consisted of gold, composite, and gold and were examined for more than 90% of all restorations. In group A, 13.3% of the restorations were scheduled for replacement. The mean period of time for replacement were secondary teeth, blood donors, and children. The mean age of the failed restorations was 56 years in the median age of the successful restorations in situ among the regular patients (group A). The data included men and ages of 20 years for gold restorations, 24-28 years for composite restorations, and 7-8 years for composite restorations. The restorative age were influenced by the type and size of the restorative, the restorative material used, and possibly also the intra-canal location of the restorations.

Publication Types:
• Clinical Trial
• Randomized Controlled Trial

PMID: 78240 [PubMed - indexed for MEDLINE]
Clinical studies
1. Observational
2. Experimental

What is our principal clinical question/problem?

1. Which material group perform best?
   i.e. a question of Therapy
1. Which material group perform best?

2. Which product within the material group performs best?
   i.e a question of Therapy

The best intervention? i.e a question of therapy

Study requirements:

- Random allocation of the participants to the alternative interventions
- Outcome measures of known or probably clinical importance for at least 80 per cent of participants who entered the investigation
- A statistical analysis consistent with the study design.
How long will these restorations last? (At what stage is more benefit than harm done by replacing them?)

What will follow the intervention?... i.e a question of prognosis. Study requirements:

- An inception cohort of persons, all initially free of the outcome of interest
- Follow-up of at least 80 per cent of patients until the occurrence of either a major study criteria or the end of the study
- A statistical analysis consistent with the study design.

Clinical studies
- Observational
- Experimental
  1. Controlled trials
  2. Prognosis
What can you show with a trial?

The truth

<table>
<thead>
<tr>
<th>A is better than B</th>
<th>A is no better than B</th>
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What the trial shows

A is better than B
A is no better than B

The truth

<table>
<thead>
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</table>

What can you show with a trial?

Type 1 error
Alfa error
Optimism error

The truth

<table>
<thead>
<tr>
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<tr>
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<tr>
<td>✗</td>
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</tbody>
</table>

What the trial shows

A is better than B
A is no better than B

Type 1 error

1. Poor study design
Effects of inadequate (RCT) study design on results


Type 1 error
1. Poor study design
2. Fallacies of observed clinical success
   • Spontaneous remission
   • Placebo response
   • Multiple variables in treatment
   • Radical versus conservative treatment
   • Over-treatment
   • Long-term failure
   • Side effects and sequelae of treatment

What can you show with a trial?

The truth

What the trial shows

Type 2 error
Beta error
Pessimism error

A is no better than B

A is better than B

√

X

√

A is no better than B

A is better than B

√

X

The truth
Type 2 error

1. Underpowered study
2. Fallacies of observed clinical failure
   • Wrong diagnosis
   • Incorrect cause-effect correlation
   • Multifactorial problem
   • Lack of cooperation
   • Improper execution of treatment
   • Premature evaluation of treatment
   • Limited success of treatment
   • Psychological barriers to success

Clinical studies

1. Observational
2. Experimental
   1. Controlled trials
   2. Prognosis

Prognosis – likelihood estimates

• Proportion of survival or success according to some specific criteria after a given temporal interval, e.g. after 1 or 5 years
• Median time of survival (in years), where 50% of the study unit, e.g. the patient, prosthesis, restorations or tooth, have failed, or
• Survival curves – describe for each time unit along a horizontal axis estimates of the proportion of the study unit that remain intact according to survival or success according to some specific criteria
Survival Curves

- Sjögren et al. J Prosth Dent 1999
- Malament et al. J Prosth Dent 1999

Hemmings et al. J Prosthet Dent 2000


Sjögren et al. J Prosth Dent 1999

Malament et al. J Prosth Dent 1999

Aquilino et al. J Prosthet Dent 2001

Prognosis - Precision of the likelihood estimates

- All good clinical prognosis studies include measures of confidence intervals for prognosis-estimates
- A 95% confidence interval consists of two values that indicating an interval where we can be 95% certain that the true value lies
- A narrow confidence interval is an indication of a precise estimate of the true value

Etch bridges
Creugers et al. J Dent 2001

Implants freestand vs connected
Naert et al., Clinical Oral Implants Research, 2001

Malament et al. J Prosth Dent 1999

# Studies on longevity of metal ceramic and alloys
PubMed/Medline

914
157
157

Trials

16
157
### Strength of evidence: Clinical performance of alloys and metal ceramic restorations

<table>
<thead>
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<th>Type of Evidence</th>
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<td>Systematic reviews</td>
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<tr>
<td>Clinical evidence</td>
<td>157</td>
</tr>
<tr>
<td>Laboratory experiments</td>
<td>877</td>
</tr>
</tbody>
</table>

1. A large volume of the literature consists of narrative reviews
2. Extrapolation from laboratory data is often used uncritically
3. Many clinical studies are not appropriately designed to demonstrate clinical superiority and/or for survival estimations
4. Most RCTs are small & underpowered
5. Majority of clinical studies use surrogate outcomes and not patient-focused criteria
6. Most clinical trials studies are done in secondary settings- not real-life dentistry
Strength of evidence
Clinical performance of alloys and metal ceramic restorations

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<table>
<thead>
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<tr>
<td>4: Opinions, descriptive studies, narrative reports, etc.</td>
<td>877</td>
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</table>

Laboratory tests - clinical relevance? 1/2

**Static stresses**
- Compressive (crushing) strength, 1h & 24 h
- Tensile strength, 15 min.
- Transverse strength, 1h & 24 h
- (Flexure/bending/modulus of rupture)
- Modulus of elasticity (Young's Modulus)
- Shear modulus

**Dynamic tests**
- Compressive modulus
- Tensile modulus
- Bending modulus
- Resilience
- Fatigue
- Fracture toughness

Laboratory data - clinical relevance? 2/2

**Other defined tests**
- Flow (Creep) 3-24 h
- Dimensional change 5 min -24 h
- (Polymerization/setting contraction/expansion)
- Hardness
- Thermal Expansion Coefficient
- Water solubility
- Water sorption

**Other undefined tests**
- Abrasion resistance (Wear)
- Adhesion
- Surface roughness
- Margin leakage
Strength of evidence
Clinical performance of alloys and metal ceramic restorations

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
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<td>4: Opinions, descriptive studies, narrative reports, etc.</td>
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<tr>
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Quality and longevity of metallic restorations

Quality of dental restorations
- Longevity curves of varying materials and lengths of survival?
Quality of dental restorations

- Longevity curves of varying materials and lengths of survival?
- Odds ratios to show relationships between clinical variables and quality and longevity in various segments of patient populations.

### Independent variables

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<td>40+</td>
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<td>Material</td>
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<tr>
<td>Amalgam</td>
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<tr>
<td>Composite</td>
<td>1.12</td>
<td>NS</td>
<td>0.13 - 1.56</td>
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<td>Glass ionom.</td>
<td>3.12</td>
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<td>2.52 - 4.34</td>
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<td>Mandible</td>
<td>1.88</td>
<td>-</td>
<td>1.17 - 2.04</td>
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<td>Maxilla</td>
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</table>
Quality of dental restorations

- Longevity curves of varying materials and lengths of survival?
- Odds ratios to show relationships between clinical variables and quality and longevity in various segments of patient populations.
- Scoring criteria according to different evaluation systems to describe the technical excellence of restorations.
Quality of dental restorations

The risk of jeopardising the integrity of remaining dental and oral tissues and the extent to which the form, function and properties of the tooth is imitated to the patient's satisfaction and maintained over time.

“Longevity data”
Numerical measures of the quality and longevity of dental restorations can be regarded simply as a consequence of either a correct or an incorrect treatment decision approach.

FDI World Dental Federation 2001

Replacement of restorations

Which factors determine my treatment decision?

• Do we know which factors that influence our decisions to replace restorations?
• A number of both objective and subjective factors have been identified.
What takes place when considering replacement of a restoration?

- A consideration if more good than harm is done by replacing restorations, i.e. a risk-benefit analysis.

- What must an examination include so a risk-benefit analysis can be carried out?
  
  - Appraisal of the presence or absence of markers of oral disease.
  
  - Error to focus attention on the appearance of the restorations.

Restoration quality in relation to the state of oral disease

1. Consider my patient's overall risk profile.
Step 1: Overall risk profile
- Lack of compliance to a recall program or irregular dental attendance
- Presence of a systemic disease
- Medication side effects
- Cigarette smoking
- Dietary habits
  - Frequency of sugar intake
  - Availability of snacks
- Use of fluorides
- Social deprivation
- Low knowledge of dental disease
- Low dental aspirations
- History of repeated interventions

Restoration quality in relation to the state of oral disease

1. consider my patient's overall risk profile
2. look for key risk markers of oral disease
Step 2: Key risk markers of oral disease

- Previous caries experience or loss of periodontal support in relation to the patient's age
- Full mouth plaque and/or bleeding scores
- Saliva quantity and quality
- Prevalence of residual pockets

1. Consider my patient's overall risk profile
2. Look for key risk markers of oral disease
3. Look out for pathogenic conditions or detect risk markers of a progressive oral disease

Step 3: Pathogenic conditions and risk markers of progressive oral disease

- Inflammatory periodontal parameters and their persistence
- Caries and caries location
- Presence of ecological niches with difficult access such as furcations
- Presence of iatrogenic factors such as restoration discrepancies
Stepwise risk assessment

1. Overall risk profile
2. Key risk markers of oral disease
3. Pathogenic conditions and risk markers of progressive oral disease
4. It is not until this stage that concern about the technical excellence of a particular restoration should be addressed in context with the estimate of possible risk for disease progression at a particular tooth site.

USPHS – Caries (Cvar & Ryge, 1973)

Test: Visual inspection, with explorer and mirror if needed

Alfa: No evidence of caries contiguous with the margin

Bravo: Explorer catch or resist removal after insertion with moderate to firm pressure, and evidence of softness. Alternatively, opacity of the margin, as evidence of undermining or demineralization, or etching or a white spot as evidence of demineralization.
USPHS - Margin adaptation

Test: Lightly draw a sharp explorer back and forth across the margin. If catch, inspect for crevice with mirror if needed.

**Alpha:** Explorer does not catch. No visible evidence of crevice.

**Bravo:** Explorer catches, and there is visible evidence of a crevice into which the explorer will penetrate. Dentin or base is not visible.

**Charlie:** Explorer penetrates into crevice that is of such depth that dentin or base is exposed.

**Delta:** Restoration is fractured, mobile, or missing.
Inlays/onlays - margins
Gold: 25-50 um
Composite inlays: 50-200 um
Ceramic inlays: 50-200 um

Probe as a diagnostic tool?

New and old
<table>
<thead>
<tr>
<th>Study</th>
<th>Abnormal indication of coronary stent</th>
<th>Validation method and Impact</th>
<th>Relation between abnormal indication and radiographic features</th>
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<td>Klith &amp; O'Shea, 1990</td>
<td>*</td>
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<td>Kishi et al., 1994</td>
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<td>Budailey et al., 1995</td>
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<td>Pena et al., 1995</td>
<td>*</td>
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<td>Raskin et al., 1996</td>
<td>*</td>
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</table>
What is the situation in 2006?

- The oral diseases are the same
- The need for high technical excellence remains unchanged
- Better understanding of etiological mechanisms of oral diseases
- Documented effectiveness of a range of prophylactic interventions to avoid or arrest oral diseases
- Aggressive promotion of oral health care products through advertising
- Majority of the population have topical fluoride treatments 365x2 per year

Dental restorations and prognosis

- Observe?
- Repair?
- Replace?

Pain: Tissue damage: Integrity: Pulp - Caries risk - Function - Replicate
a. Observe? or
b. Repair? or
c. Replace?

Pain: -
Tissue damage: ✓
Integrity: Pulp - Caries risk - Function ✓ Replicate ✓

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Longevity – estimates from literature
Patient Information

1. Which biological/technical factors can affect the prognosis before, under and after therapy?
2. What can happen?

Survival

- Technical defects?
  - can be repaired?
  - cannot be repaired?
- Biological defects?
  - can be repaired?
  - cannot be repaired?

FPDs

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<tr>
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FPDs – what happens

<table>
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<tr>
<th></th>
<th>Randow et al. 86</th>
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<td>Fracture of restoration**</td>
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<td>-</td>
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<td>7</td>
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<tr>
<td>Esthetics</td>
<td>31</td>
<td>43</td>
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<td>12</td>
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</table>

* Variation
** Fracture also part-fracture of crown (ceram) = FDP fracture
*** Inclusive other technical complications

FPD - variables

- Patient factors
  - Age, smoking, bruxism, xerostomia
  - Intraoral localisation
  - Previous restoration of tooth
- Material factors
  - Alloy --- ceram
  - Cement type
- Selection factors
  - Vitality
- Construction factors
  - Preparation
  - Post type
  - Extension
- Follow up and hygiene

Patient age

No clear conclusions
- Increased risk med alder
  - x4 Kerschbaum et al., 1991
- No increased risk with age
  - Glantz et al., 1984, Karlsson, 1989, Leempeol et al., 1995
Intraoral localisation

n=408 / 107 pas.

Previous treatment


Material factors - alloy

- No differences between alloys
- Titan & conventional alloy equivalent
- Conventional alloy & sintered guld equivalent regarding gingiva
  Setz & Diehl. Prosthet Dent 1994
Selection factors - vitality

- Increased risk with root-filled teeth having cantilever extension
  - Randow et al., 1986; Dahl et al., 1987; Karlsson, 1989
- Uncertain/weak risk with root-filled teeth
  - Leempoel et al., 1995
- No increased risk with root-filled teeth
  - Valderhaug et al., 1997

Construction factors - extension

- Increased risk with extensions
  - Glantz et al., 1984, Randow et al., 1986, Karlsson, 1989,
- No increased risk with extensions
  - Leempoel et al., 1995

Etch bridges

1. cement
2. Preparation
3. Size

Operator
Alloy
Etch method
Intra-oral localisation

Creugers et al. J Dent 2001
Why restorative therapy?
Protect from further damage

Principles for modern restorative care
1. Remove all infected caries
2. Remove as little as possible non-caries hard tissue
3. Evaluate which material is optimal for the given circumstance
4. Adjust preparation according to selected material to replace the lost hard tissue