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BASIC RESEARCH

Clinical performance of CAD/CAM ceramic restorations a systematic review and meta-analysis

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Abstract

Purpose: to determine the long-term clinical survival rates of single-tooth restorations fabricated with CAD/CAM technology, as well as frequency of failures depending on CAD/CAM system, type of restoration, selected material and luting agent.

Materials and Methods: electronic search performed using Medline/PubMed and Embase; selected keywords and well-defined inclusion and exclusion criteria. All articles were reviewed by title, abstract, and subsequently by a full text reading. Results were statistically analyzed. Overall failure rate was calculated by random-effects model. Reported failures were analyzed by CAD/CAM system, type of restoration, restorative material and luting agent.

Results: Total of 2,628 single-tooth restorations. Mean exposure time of 7.3 years. 274 failures. Failure rate was 1.86% per year, estimated per 100 restoration years (IC 95%: 1.08% to 3.19%). Estimated total survival rate after 5 years was 91.1% (IC 95%: 89.6% to 92.5%).

Conclusions and Clinical implications: Overall survival rate of single-tooth ceramic restorations fabricated with CAD/CAM technology was similar to those conventionally manufactured.

Background and Aim

- Increased demand for all-ceramic restorations in both anterior and posterior teeth has expanded the search for materials with improved mechanical and esthetic properties. Evolution in ceramic materials is directly related to the development of computer-aided design/computer-assisted manufacture (CAD/CAM) technology. (1,2)
- To determine long-term clinical survival rates of single-tooth restorations fabricated with CAD/CAM technology, as well as the frequency of failures depending on the CAD/CAM system, type of restoration, selected material and luting agent.

Methods and Materials

- Electronic search (Fig.1) until November 2015.
- Key-words: “Computer Aided Manufacturing”, “CAD CAM”, “Computer-Aided Design” ; “Computer dentistry”, “Computer Milled Prosthesis”, “Cerec”, “Crowns”, and “Inlays”.
- Duplicates deleted. Well-defined inclusion and exclusion criteria.
- Pooled results were statistically analyzed and the overall failure rate was calculated by random-effects model.
- Reported failures analyzed by CAD/CAM system, type of restoration, restorative material, and luting agent.

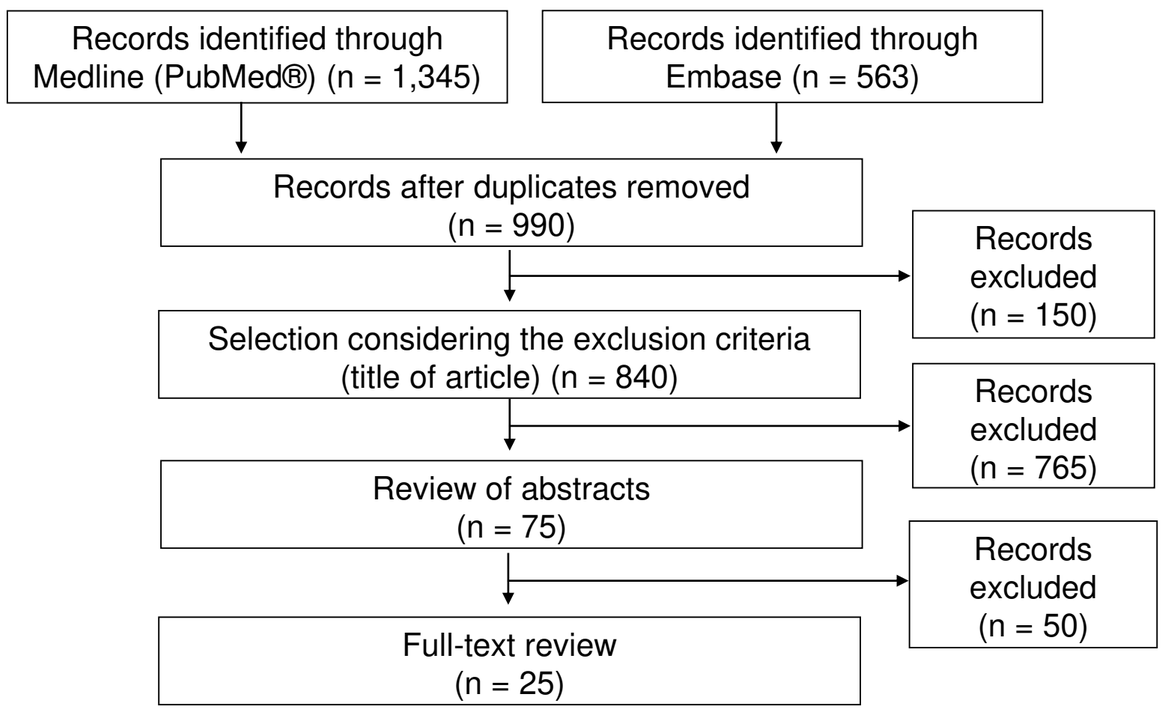

Fig. 1 – Search design and strategy

Results

- 2,628 single-tooth restorations. Mean exposure time of 7.3 years. 274 failures. **Failure rate 1.86% per year**, per 100 restoration years (CI 95%: 1.08% to 3.19%). Estimated total **survival rate after 5 years was 91.1%** (CI 95%: 89.6% to 92.5%).
- KaVo ARCTICA system had a higher failure rate when compared to Cerec 2 system (p<0.001; 1.18% vs 3.22%)
- Glass-matrix ceramic had lower failure rate when compared to polycrystalline ceramic (p<0.001; 1.18% vs 3.22%)
- Full-coverage crowns (p<0.001; 1.99%) and endocrowns (p<0.001; 2.57%) had higher failure rate then inlay/onlays restorations (1.57%)
- Chemically cured restorations (p<0.001; 2.80%) had higher failure rate then dual-cured restorations (1.75%).
- Light-cured restorations (p<0.001; 1.40%) showed a lower failure.

Table 1 - Descriptive and Failure Analysis: Overview of Exposure Time, Study Type, Location, and Failure Rate of Included Studies

Study	N.º Rest.	Study type	Tooth location	MET (y)	No. of failures	EFR* (%, CI)
Isenberg et al, 1992[75]	121	Pro	P	3	7	1.93 [0.92; 4.04]
Heymann et al, 1996[76]	42	Pro	P	3.7	0	-
Thordrup et al, 1999[77]	30	Pro	P	3	5	5.56 [2.31; 13.35]
Molin and Karlsson, 2000[78]	20	Pro	P	5	2	2.00 [0.50; 8.00]
Pallesen and Van Dijken, 2000[79]	32	Pro	P	8	9	3.52 [1.83; 6.76]
Reiss and Walther, 2000[80]	1,010	Retro	P	10.5	81	0.76 [0.61; 0.95]
Thordrup et al, 2001[81]	14	Pro	P	5	1	1.43 [0.20; 10.15]
Otto and De Nisco, 2002[82]	187	Pro	P	10.3	15	0.78 [0.47; 1.30]
Bindl and Mörmann, 2002[83]	43	Pro	P	3.3	2	1.43 [0.36; 5.72]
Reich et al, 2004[84]	54	Pro	A / P	3	2	1.24 [0.31; 4.94]
Sjögren et al, 2004[85]	61	Pro	P	10	7	1.15 [0.55; 2.41]
Bindl and Mörmann, 2004[86]	36	Pro	A	3.7	2	1.49 [0.37; 5.96]
Fasbinder et al, 2005[87]	71	Pro	P	3	3	1.41 [0.45; 4.37]
Bindl et al, 2005[88]	208	Pro	P	4.6	32	3.36 [2.38; 4.75]
Federlin et al, 2007[89]	28	Pro	P	3	1	1.19 [0.17; 8.44]
Guess et al, 2009[90]	23	Pro	P	3	1	1.45 [0.20; 10.29]
Kokubo et al, 2009[91]	75	Pro	A / P	6.4	9	1.87 [0.97; 3.59]
Beuer et al, 2010[92]	50	Pro	A / P	2.9	0	-
Vanoorbeek et al, 2010[93]	85	Pro	A / P	2.8	9	3.80 [1.97; 7.29]
Kokubo et al, 2011[94]	89	Pro	A / P	5	5	1.12 [0.47; 2.70]
Vigolo and Mutinelli, 2012[95]	39	ECA	P	5	3	1.54 [0.50; 4.77]
Örtorp et al, 2012[96]	143	Retro	P	5	19	2.66 [1.69; 4.17]
Passia et al, 2013[97]	77	ECA	P	4	53	17.21 [13.15; 22.52]
Reich and Schierz, 2013[98]	29	Pro	P	4.3	1	0.81 [0.11; 5.76]
Otto and Mörmann, 2015[99]	61	Pro	P	10.7	5	0.77 [0.32; 1.84]
TOTAL SUMMARY	**2,628**	**Pro: 52%; Retro: 44%; RCT: 4%**	**A: 2,3%; P: 88,2%; ND: 9,5%**	**7.3**	**274**	**1.86 [1.08; 3.19]**

*per 100 restoration years. MET= Mean exposure time; EFR= Estimated failure rate; CI= Confidence interval; P= Posterior; A= Anterior; ND= not defined; Pro= Prospective; Retro= Retrospective

Table 2 - CAD/CAM System, Restoration Type, Material Type, and Type of Luting Agent Effects on Failures

	N.º Rest.	% of all studies	MET (y)	*p* value	EFR*ɣ (%, CI)	ESR after 5 years* (%, CI)
CAD/CAM system						
Cerec 1	1,412	24	6.7	0.805	1.41 [0.75; 2.63]	93.2 [91.2; 94.7]
Cerec 2†	378	28	4.4	-	1.95 [1.30; 2.92]	90.7 [85.1; 94.3]
Cerec 3/inLab	315	22	4.7	0.960	1.47 [0.62; 3.48]	92.9 [88.1; 95.8]
GN-1 system	174	8	3.9	0.868	2.14 [0.65; 7.05]	89.9 [79.6; 95.1]
Procera	237	10	5.5	0.095	2.35 [1.65; 3.37]	88.9 [82.1; 93.2]
Lava	20	2	5.0	0.589	1.00 [0.14; 7.10]	95.1 [42.9; 99.7]
KaVo ARCTICA	77	4	4.0	<0.001	17.21 [13.15; 22.52]	42.3 [27.3; 56.5]
Celay	15	2	3.0	0.139	6.67 [2.15; 20.67]	71.6 [18.0; 93.7]
Restoration type						
Core crown	467	26	4.0	0.810	2.24 [1.52; 3.31]	89.4 [83.8; 93.1]
Crown	323	18	5.2	<0.001	1.99 [0.56; 7.12]	90.5 [87.1; 93.1]
Inlay/onlay†	1,661	49	5.4	-	1.57 [0.99; 2.48]	92.5 [90.5; 94.0]
Endocrown	120	4	6.1	<0.001	2.57 [0.62; 10.55]	87.9 [79.0; 93.2]
Reduced crown	54	2	3.8	0.196	2.94 [1.40; 6.17]	86.3 [65.1; 95.1]
Veneer	3	1	3.0	0.745	-	-
Material type						
Glass-matrix ceramic	2,122	74	5.4	<0.001	1.18 [0.74; 1.89]	94.3 [93.0; 95.3]
Polycrystalline ceramic†	435	22	4.4	-	3.22 [0.98; 10.53]	85.1 [80.4; 88.8]
Resin-matrix ceramic	71	4	2.9	0.086	3.86 [1.16; 12.84]	82.4 [59.2; 93.2]
Luting agent						
Chemically cured	460	26	5.0	<0.001	2.80 [0.92; 7.62]	86.9 [82.1; 90.5]
Light-cured	512	20	5.8	<0.001	1.40. [0.62; 3.15]	93.2 [91.4; 94.7]
Dual-cured†	1,656	54	5.5	-	1.75 [1.09; 2.80]	91.6 [88.6; 93.9]
SUMMARY	**2,628**	**100**	**7.3**	**-**	**1.86 [1.08; 3.19]**	**91.1 [89.6; 92.5]**

* Based on random-effects; † Reference variable; ɣ Per 100 restoration years; MET= Mean exposure time; EFR= Estimated failure rate; ESR= Estimated survivel rate; CI = Confidence interval

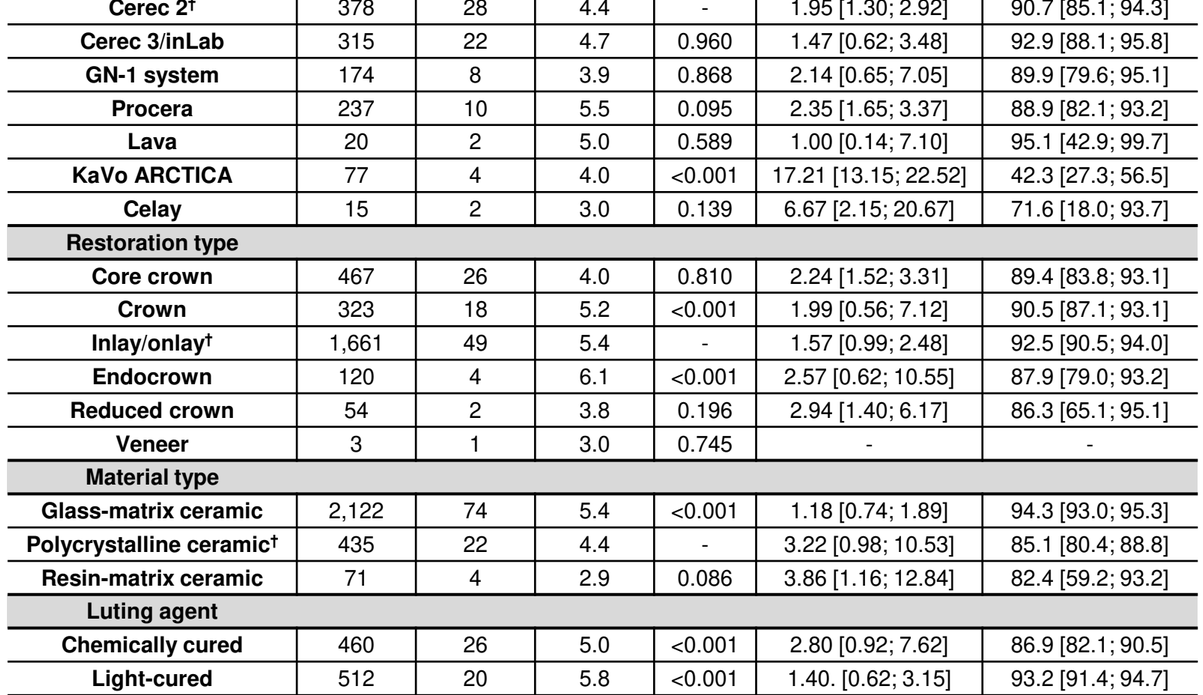

Fig. 2 - Forest plot: random meta-analysis of failure rate

Conclusions

Survival rate of single-tooth ceramic restorations fabricated with CAD/CAM technology is similar to conventionally manufactured.

References

1. Miyazaki T et al. A review of dental CAD/CAM: current status and future perspectives from 20 years of experience, *Dent Mater J 2009; 28(1): 44-56.*
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Presented at EAO EUROPEAN ASSOCIATION FOR OSSEOINTEGRATION CONGRESS JOINT MEETING SEPES Sociedad Española de Prótesis Estomatológica y Estética
MADRID FROM OCTOBER 5TH TO OCTOBER 7TH, 2017