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Health Technology Assessment of CAD/CAM in Dentistry

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Abstract

Introduction: Computer-Aided Design and Computer-Aided Manufacturing (CAD/CAM) are the latest achievements of Prosthodontics and Restorative Dentistry. The aim of this research is to help make appropriate decision whether to use this technology in Iran.

Methods: Studies were included in this review that compared Dental CAD/CAM with conventional restorative methods in terms of safety, efficacy and cost-effectiveness using Cochrane Library, CRD and Pub med. Results were analyzed using qualitative methods.

Results: Six articles were used. Different indices of effectiveness in two types of application were found through the studies. Total failure rate for dental inlays was obtained as 0, 2.6% in 3 studies during a 4-year period and 1.75% in a 7-year period. It was 0.53% and 3.61% in two studies for prosthesis. Five-year survival rate for dental inlays was obtained from 91.6% to 100% and for prosthesis 72.2% to 100% in two studies. In terms of cost-effectiveness ratio of this technique compared to traditional methods, using ceramics fabricated along with chair side CAD/CAM is higher than traditional method; thus using it provides higher cost-effectiveness ratio than restoration by gold.

Conclusion: This technology seems to be safe and effective and if this application is performed by specialists in the field of prosthetics, it will have favorable results. Although this HTA study confirmed the cost effectiveness of the dental CAD/CAM, economic evaluation of the technology in Iran is recommended for the future.

Keywords: Cerec, Dentistry, Review

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1. Introduction

Industrial countries have recognized importance of technology assessment in dentistry care for about one decade; however, it seems that dentistry technology assessment is done less than medical assessments, even if there is potential need for them. Technology assessment in dentistry is required due to rapid growth in published research papers and increasing costs of dentistry care as well as selection of new and therapeutic methods in dentistry. Currently, the government and health insurers have difficulty in covering dentistry services and they are under pressure to put source of this cost transaction for treatment choices based on the clinical effectiveness and cost-effectiveness [1]. To this end, Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) technology is one of the latest achievements of Prosthodontics and Restorative Dentistry. Using scanners and laser cameras, the information of the patient's mouth or plaster model provided in the form of the teeth is passed to a processor and manufacturer system. Then using ceramic blocks such as zirconia and alumina with high strength and density, a skeleton is made with high precision and quality in a shorter time by three-dimensional CNC (Computer Numeric Control) lathe machine. Prosthetic skeleton with ceramic structure replaces conventional metal skeleton in crowns and bridges using this technology. Conventional metal skeletons are made during the casting process and with relatively large errors. This technology is able to design and implement single crowns to full-arch-fixed dental prostheses including the whole jaw. Adjustable angles for CNC Lathe if necessary by the dentist, capability of evaluation and selection of the Pontic (spaces between the teeth) with respect to the oral condition of the patient, capability of evaluation and selection of teeth for a bridge to connect to each other, capability of selection of curvature angles for connections, speed, precision and beauty are among advantages of this technology for making dental prostheses. The disadvantage is the high cost for the dentist and patient [2]. The past decade witnessed increasing demand for all ceramic inlays for both anterior and posterior teeth, and it caused increased search for the material with higher quality. Thus needs for modern inlays with effective predictable outcomes led to entry of stronger, more stable material with beautiful appearance and high biocompatibility in the

market. Need for homogenous quality of the material, reduced cost of production. Standardization of manufacturing process confronted the authors with the fact that they should look for replacement of conventional manual process with CAD/CAM process. Development of CAD/CAM technology has recently become rapid in the field of dental inlays. Introduction and promotion of such techniques to clinical area should be based on relevant scientific evidence. Unfortunately, there are rare randomized controlled trials in this regards [3]. The aim of this research is to help appropriate decision making concerning using this technology in Iran by assessment of efficacy, cost-effectiveness and safety of this technology, particularly with respect to our country's condition.

2. Methods

Considering the search focus, secondary studies, systematic reviews, economic evaluations and health technology assessments (HTA) were collected. In the first step, Cochrane Library was searched from 1990 to November 2010. To ensure complete electronic search, Centre for Reviews and Dissemination (CRD), as well as PubMed and Google Scholar were searched. No language restriction was considered through the search, though finally all retrieved papers had English abstracts. After checking the title and abstract of papers, non-English papers were excluded. Remaining papers were retrieved in summary form and two authors separately reviewed them. Finally, 39 papers were entered to the final evaluation phase. They were independently evaluated by two reviewers. The aim of this evaluation was controlling inclusion and exclusion criteria according to initial definitions. To this end, papers on chemical textures and materials or on techniques irrelevant to dentistry were removed.

Six papers were included in the study in this step and 33 papers were eliminated. Search strategy in this study included:

#1) computer aided design computer aided manufacturing
#2) MeSH descriptor computer aided design computer aided manufacturing explode all trees
#3) CAD/CAM
#4) computer aided*
#5) (#1 OR #2 OR #3)
#6) dent*
#7) (#5 AND #6)

3. Results

Among six included papers, five were systematic review [3-7] and one was health technology assessment [1]. Three studies were conducted in 2009 [4, 6, 7], one was done in 2005 [1], one was done in 2003 [5] and one was done in 1999 [3]. Two papers were published in USA [4, 7], two in Germany [1, 6], one in Japan [5] and one in UK [3]. Results retrieved from six remaining papers were analyzed qualitatively in effectiveness and economic evaluation groups.

a) Effectiveness: In Martin's study which investigated clinical performance of ceramic inlays, intra-coronal restorations made by CEREC system was considered as a successful method in filling process (with 97.4% survival rate average during 4.2-year period). This study also emphasized reasons and failure rates of this type of filling. Dominant reasons for failure include failure of ceramic, support tooth failure, and postoperative high sensitivity and adhesive mid-coating (lute). Ceramics made by CEREC system measure useful filling to a successful rate. These fillings are stable in terms of the color and they are clinically in acceptable rate. Using luting composite on occlusal

Table 1. Papers included in the study

No.	Title	Authors	Search Years	Type of study	Year of publication	Country
1	Technology assessment in dentistry: A comparison of the longevity and cost-effectiveness of inlays [1]	Gandjour et al	1996-2003	Health Technology Assessment	2005	Germany
2	Clinical performance of CEREC ceramic inlays: a systematic review [3]	Martin et al	1997-1986	Systematic review	1999	UK
3	Computer-Aided design and Computer-Assisted Manufacturing in prosthetic implant dentistry [4]	Kapos et al	1996-2008	Systematic review	2009	USA
4	Systematic review of ceramic inlays [5]	Hayashi et al	1990-2001	Systematic review	2003	Japan
5	Survival and complications of computer aided-designing and computer-aided manufacturing vs. conventionally fabricated implant-supported reconstructions [6]	Harder et al	2004-2008	Systematic review	2009	Germany
6	A systematic review of clinical performance of CAD/CAM single tooth restoration [7]	Wittenben et al	1985-2007	Systematic review	2003	USA

surfaces leads to the phenomenon known as submargination. Failure of ceramic, mid-coating and high postoperative sensitivity is yet related problems which require further studies [3]. Kapos studied the use of CAD/CAM in *dental implant prosthetics* and showed clinical studies about application of these techniques are preliminary for providing significant conclusions concerning abutments and framework functioning and have low statistical power. Impact of abutments made by CAD/CAM on tissues around the implant as well as effect of frameworks made by CAD/CAM on survival of veneered porcelain has not been evaluated scientifically yet [4]. Harder's work which evaluated complexities and survival of CAD/CAM against implant restorations made traditionally indicated that 5-year survival rate of implants made as Fixed Prosthodontics in the form of full-arch-fixed dental prostheses (FDPs) is in range 81.4%-95.6%. Survival rates reported for implants made as all-ceramic single crowns (SC) is 100%. Five-year survival rate for Fixed Prosthodontics in the form of full-arch-fixed dental prostheses is between 72.2 and 100%.

Table 2. Effectiveness indicators used in the studies and their results

Failure-free years			Survival rate-4 years	Survival rate-5 years		Total failure rate		Author	Name and type of study
-----			-----	91.6%: [95% confidence interval (CI): 88.2%-94.1%]-(Within a 5-year period).		Annually 1.75%: [95% confidence interval (CI): 1.22%-2.52%]-(during a 7.9- year period)		Wittenben et al. 1985-2007	A Systematic review of clinical performance of CAD/CAM single tooth restoration"[7]
-----			-----	-----		Abutment category	prostheses	Kapos et al. 1966-2008	"Computer-Aided Design and Computer-Assisted Manufacturing in Prosthetic Implant Dentistry[4]
						Ceramic abutment			
						NO significant Failure	0.53%		
-----			-----	-----		ceramic inlay in comparison with other restoration (metallic inlay, gold inlay)		Hayashi et al. 1990-2001	Systematic review of ceramic inlays [5]
						There was no significant difference with ceramic inlays, an odds ratio of 1.12 :(SE 1.48; 95% CI 0.08, 15.0; P=0.98).			
-----			97.4%	-----		2.6% (within a 4-year period)		Martin et al. 1986 to 1997	Clinical performance of CEREC ceramic inlays: a systematic review [3]
Laboratory fabricated ceramic	chair side CAD/CAM ceramic	gold inlays	-----	-----		-----		Gandjour et al. 1966-2003	Technology assessment in dentistry: a comparison of the longevity and cost-effectiveness of inlays [1]
8.62 (95 percent confidence interval, 8.40-8.85)	8.65 (8.58-8.73)	8.76 (8.72-8.80)							
-----	-----	-----	-----	(SCs)	(FDPs)	(SCs)	(FDPs)	Harder et al 2004-2008	" Survival and complications of computer aided-designing and computer-aided manufacturing vs. conventionally fabricated implant-supported reconstructions "— Systematic review [6]
				100% [95% confidence interval (CI): 92.4-100].	72.2% to 100%	0.43% [95% confidence interval (CI): 0.06-3.06].	3.61% [95% confidence interval (CI): 2.05-6.36].		

Five-year survival rate for all-ceramic single crowns (SC) is 100%. Assessed annual failure rate for veneering material, for implants made as SC form, and for implants made as Fixed Prosthodontics in the form of FDP is 3.61% [6]. In a study by Wittneben, clinical performance of Single tooth Restoration by CAD/CAM was investigated and following results were obtained: among total 1957 Single tooth Restorations with average exposure of 7.9 years and 170 failures, annual failure rate was 1.75% (with confidence interval 95%: 1.22% - 2.52%). Total survival rate after 5 year was 91.6% (with confidence interval 95%: 88.2% - 94.1%) [7]. **b) Economic evaluation:** In a study by Gandjour, dental inlays within a 9-year period were studied. It was found that failure-free years were 8.62 (95% confidence interval, 8.40-8.85), 8.65 (8.58-8.73) and 8.76 (8.72-8.80) for Laboratory fabricated ceramic, chair side CAD/CAM ceramic, and gold inlays, respectively. Gold inlays significantly have higher cost and failure-free survival compared to ceramic fabricated by CAD/CAM and thus incremental cost-effectiveness 487 Euro (95% confidence interval, 456-518) per each failure-free year would be obtained. In sensitivity analysis for a 4-year period, incremental cost-effectiveness ratio for gold compared to ceramic fabricated by chair side CAD/CAM was 1082 Euro (95% confidence interval, 287-2254) per each gained failure-free year. Laboratory fabricated ceramics were the most expensive inlays, while ceramic fabricated in laboratory, ceramics fabricated by chair side CAD/CAM and gold inlays had similar failure-free survival rates, laboratory fabricated ceramics had the highest cost and thus had lower cost-effectiveness compared to ceramics fabricated by chair side CAD/CAMand gold inlays [1].

4. Discussion

Considering included studies in this work, effectiveness of CAD/CAM technology can be investigated in two fields as follows: 1) use of this technology for fabrication of dental implants and their abutment, and 2) for fabrication of dental inlays. Different effectiveness indices for two applications were found in the studies. It was attempted to include them in the effectiveness table. Total failure rate for dental inlays was 2.6% in a 4-year period and 1.75% in a 7-year period [3, 7]; Otto et al, showed that the failure rate was 8% in a 10-year period [8] and Posselt et al, reported 35 failures in a 9-year period for 2,328 inlays and onlays [9]. Berg et al, showed three fractures in 115 inlays in a five years period [10]. The total failure rate were 0.53% and 3.61% in two studies for prosthesis [4, 6]. Five-year survival rate for dental inlays was obtained from 91.6% to 100% and 72.2% to 100% for prosthesis in two studies [6, 7]; Brauner et al, reported a survival probability of 88% in a 67 month period for 238 inlays [11]. Reiss et al, indicated lower survival rates for Cerec inlays [12]. Sjögren et al, showed the survival probability was 89% for inlays after 10 years [13]. Cost-effectiveness of this technique compared to traditional methods in the single health technology assessment indicated that using ceramics fabricated by chair side CAD/CAM has higher cost-effectiveness than traditional method; thus using it provides higher cost-effectiveness than restoration by gold [1]. Regarding the safety of the technique, it should be stated that no complication or adverse event caused by this device was mentioned in the reviewed studies. This device is gaining license from US Food and Drug Administration.

5. Conclusion

Although this HTA study confirmed the cost-effectiveness of the dental CAD/CAM, however economic evaluation of this technology in Iran is recommended for the future.

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Authors' Contribution

Mobinizadeh M contributed to design, data collection, data analysis and drafting. Doaee SH contributed to design, data collection, data analysis and drafting. Olyaeemanesh A contributed to design, drafting and supervision. Azadbakht M, Nejati M, aboee P contributed to design and data collection.

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