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Success of Complete Denture Treatment, Detailed Investigation of Construction Protocols, Occlusal Schemes and Evaluation Questionnaires

SUMMARY

Background/Aim: *The successful outcome of conventional complete denture treatment can be defined with the use of both subjective and objective criteria. Denture satisfaction determinants may include denture quality, oral tissue condition, patient-dentist relationship, patient's attitude toward dentures, patient's personality and socioeconomic factors. Purpose: The aim of the current review was to identify and analyze the different construction protocols and occlusal schemes that contribute to the success of complete denture rehabilitation through the use of evaluation questionnaires.* ***Material and Methods:*** *A comprehensive literature search was performed through electronic databases (MEDLINE via PubMed) using the appropriate key words (complete denture construction, complete denture fabrication, complete denture occlusion and complete denture occlusal scheme). The related to the subject scientific papers were selected and evaluated for eligibility utilizing a predefined review process (English, full text articles, published from January 2000 up to April 2017).* ***Results:*** *None of the analyzed studies identified significant differences between dentures constructed with simplified, CAD/CAM and traditional protocols in terms of general satisfaction and Oral Health Related Quality of Life scales. The same condition applied to the studies which compared complete dentures with bilateral balanced, lingualized, monoplane and canine guided occlusion.* ***Conclusions:*** *Current scientific evidence suggested that patients could adapt comfortably to any type of bilateral balanced occlusal scheme and to complete dentures been fabricated with all types of complete denture construction protocol. Disease-specific questionnaires could be considered valuable tools and should be used to assess the outcome of any treatment modality.*

Key words: Complete Denture, Construction Protocol, CAD/CAM, Occlusal Scheme, Lingualized Occlusion, Satisfaction, Questionnaires, Ohrqol

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Introduction

Conventional complete denture (CD) rehabilitation has been established as a valuable treatment modality despite major advancements in implant dentistry[1]. Biomechanical complications[2], surgical procedures' risk[3] and overall cost of prosthetic components and procedures[4,5] have been advocated as the main reasons for patients not selecting the implant-assisted removable prostheses as their treatment of choice.

The laboratory fabrication procedures of a CD have remained largely unchanged since the introduction of poly-methyl-methacrylate (PMMA) by Hill in 1931[6]. The standardized denture construction protocols could be divided into two main categories: a) conventional construction, which included the traditional, the simplified

and the CAD/CAM protocols and b) duplication construction protocols.

Most undergraduate academic curricula in the United Kingdom and in the United States have adopted the traditional construction protocol as their teaching method for conventional CDs[7,8]. The simplified construction protocol, although it could be considered less labor-intensive and time-consuming than the traditional protocol, has been granted limited application by the dental schools[9]. The main difference of a simplified protocol compared to a traditional protocol has been established as the one step impression technique versus the two-step one[10]. Several randomized controlled trials[11–17] have been published which compared the subjective and objective outcomes of these two construction protocols and no definitive result could been drawn as to their effectiveness.

Recently, the concept of computer-aided design and computer-aided manufacturing (CAD-CAM) has been introduced as an alternative CD construction protocol[18]. Computer-engineered complete dentures (CECD) could be either digitally designed or digitally fabricated, with both additive methods (rapid prototyping-printing) and subtractive methods (CNC milling)[19]. Due to the fact that CAD-CAM construction protocols have not been widely used, only a few published clinical studies[20,21] could be utilized for assessing this new technique.

The second main group for the standardized CD construction protocol comprised the duplication of the existing dentures with various techniques[7]. The main advantage of replicated dentures could be considered the more comfortable adaptation of elderly patients to their new prostheses[22]. The inherent difficulties of randomization in a study design between traditional and duplication construction protocols led to only non-randomized clinical studies[23–25] been published to the literature up to date.

It has been established that the crucial difference between a CD and a natural dentition was that dentures act as one unit and transfer the energy being applied to the whole denture base, while the natural teeth act as single units[26]. That fact led the dental profession to adopt the dogma of bilateral balanced occlusion for CDs in order to minimize lateral forces been applied to the residual ridge[27]. It has also been speculated that non-balanced monoplane occlusion exhibited lower masticatory efficiency and led to poorer patient satisfaction[28]. Various concepts of balanced occlusion (i.e. lingualized) and non-balanced occlusion (i.e. canine-guided) have been investigated through numerous randomized clinical trials[29–42].

Psychometric questionnaires have been developed to register patients' feedback for the evaluation of their denture treatment. The term Oral Health-Related Quality of Life (OHRQoL) was proposed by Gift and Redford[43] to record the impact of patients' oral disease to everyday social activities. The Oral Health Impact Profile-20 (OHIP-20) was developed to measure the impact of complete dentures to the OHRQoL of edentulous patients[44]. Additionally, in order to record the patients' self-perceived satisfaction, Awad and Feine[45] proposed the McGill denture satisfaction instrument. The validity and reliability of questionnaires related to complete denture assessments have been well established in several clinical studies[46-49].

The aim of the current review was to summarize the results of all clinical studies addressing the subjects of complete denture construction and their occlusal schemes. The subject of the evaluation questionnaires was also critically analyzed, but in an indirect approach, through the results of the reviewed papers.

Material and Methods

An electronic database (MEDLINE/Pubmed) search was performed to retrieve relevant articles, dated from January 2000 until April 2017. It involved full-text papers, published in English with the following search terms: "complete denture construction", "complete denture fabrication", "complete denture occlusion" and "complete denture occlusal scheme". Boolean operators (or, and) were used to combine searches. Additionally, a manual search was performed to the following dental journals: Journal of Prosthodontics, Journal of Prosthetic Dentistry, the International Journal of Prosthodontics, and the Journal of Oral rehabilitation.

The inclusion criteria, apart from full text articles written in English, were human clinical studies with or without a randomization process. The exclusion criteria were studies with implant-assisted or teeth-supported overdentures, in vitro studies, case reports and review papers. The reports were analyzed by two separate reviewers to check the papers' relevancy to the study subject. In cases of disagreement, a third reviewer was consulted to achieve consensus. The reviewers were not blinded as to the authors' names or the journal of publication.

Results

Two separate searches were performed. The first identified 331 articles related to the subject of denture construction protocols, out of which only 12 studies (Table 1) met the inclusion criteria. The second search related to the subject of denture occlusion, identified a total of 449 articles, with only 14 studies (Table 2) been selected for final analysis.

Table 1. Summary of studies assessing complete dentures' construction protocols.

Study (year)	Study design	Sample size (n)	Construction protocols	Variables (instruments)	Follow-up (months)	Patients' preference
Nunez et al[17] (2015)	RCT	50	Simplified vs Traditional	OHIP-EDENT, satisfaction	Baseline, 1 m, 6 m	No difference
Vecchia et al[16] (2014)	RCT	39	Simplified vs Traditional	Total cost, fabrication time, # of adjustments	Baseline, 3 m, 6 m	Not applicable clinical evaluation
Regis et al[14] (2013)	RCT	39	Simplified vs Traditional	OHIP-EDENT, satisfaction, FAD	Baseline, 3 m, 6 m	No difference
Cunha et al[15] (2013)	RCT	39	Simplified vs Traditional	Masticatory performance and ability	Baseline, 3 m, 6 m	No difference
Kawai et al[13] (2010)	RCT	122	Simplified vs Traditional	Total cost, fabrication time,	Baseline, 3 m, 6 m	Not applicable clinical evaluation
Heydecke et al[12] (2008)	RCT-CO	20	Simplified vs Traditional	Satisfaction	3 m, 6 m	No difference
Kawai et al[11] (2005)	RCT	122	Simplified vs Traditional	Satisfaction, denture quality	Baseline, 3 m, 6 m	No difference
Schwindling et al (2016)[21]	PCS	5	CAD/CAM vs Traditional	Clinical evaluation	Baseline	Not applicable clinical evaluation
Kattadiyil et al[20] (2015)	PCS	15	CAD/CAM vs Traditional	Satisfaction, clinical evaluation	Baseline, 1 week	CAD/CAM
Kamalakidis et al (2016)[25]	PCS	20	Duplication vs Traditional	OHIP-20, satisf., sore spots, # adj.	Baseline, 3 m, 6 m	No difference
Ellis et al[24] (2007)	PCS	40	Duplication vs Traditional	OHIP-20, satisfaction	Baseline, 1 m	No difference
Scott et al[23] (2006)	PCS	65	Duplication vs Traditional	OHIP-14, satisfaction	Baseline, 3 m	No difference

RCT: randomized clinical trial, CO: cross-over, PCS: prospective clinical study, FAD: functional assessment of dentures, #: number

Construction protocols

The search strategy yielded seven articles (Table 1) which compared traditional and simplified construction protocols. However, only four separate randomized clinical trials[11–17] could be identified. The studies evaluated patients' self-perceived satisfaction, oral health related quality of life, masticatory performance and ability, and finally fabrication time and total costs. All studies had a follow-up period of six months.

Nunez et al.[11] conducted a randomized clinical trial which compared CDs with traditional and simplified construction protocols. They utilized the OHIP-EDENT instrument and a patient satisfaction questionnaire with a Visual Analogue Scale (VAS) to record the patients' responses. Follow-up time intervals were set at one and at six months with equal acceptance rates been registered by the patients for both construction protocols.

One randomized controlled clinical trial, which was divided into three separate articles[12–14], compared the simplified protocol for complete denture fabrication with the traditional protocol. The authors focused into masticatory performance and ability[14]; patients' oral health–related quality of life, satisfaction, and denture quality[13], and finally, total cost, fabrication time and number of adjustment appointments[12]. They concluded that although patients' preference was equal for both fabrication methods, the simplified protocol was cheaper and demanded less time for denture completion.

Kawai et al.[15,16] conducted a randomized clinical trial, between simplified and traditional protocols, comprising the largest sample size (n=122) of all reviewed studies. No difference was detected in patients' preference as assessed by overall satisfaction at 3 and 6 months intervals. Denture quality was determined to be equal for both fabrication protocols. The authors also concluded that the simplified construction protocol cost significantly less and the clinicians spent less chair-time than the traditional protocol.

Finally, Heydecke et al.[17] conducted the only randomized clinical trial with a crossover study design between a simplified and a traditional construction protocol. The participants were instructed to use each denture design for three months and then rated, using a visual analogue scale, the following items: general satisfaction, ability to chew, ability to speak, esthetics, stability, comfort and ease of cleaning. No significant differences were detected between the two protocols regarding general satisfaction.

CAD/CAM dentures have only recently been introduced. As a result, no randomized control trials could be identified in the literature. A prospective clinical study by Schwindling et al.[21] comprised five participants and focused on the clinical evaluation of CDs fabricated with

a CAD/CAM and a traditional construction protocol. The patients' preference was not recorded in this study.

Kattadiyil et al.[20] conducted a prospective clinical study comparing a CAD/CAM denture construction protocol and a traditional one. They evaluated, after one week, patients' satisfaction and the clinical features of the dentures. The fifteen patients in this study exhibited a higher preference for CDs fabricated with the CAD/CAM construction protocol.

Three prospective clinical studies[23–25] were identified, that compared CDs fabricated with a traditional and a duplication construction protocol. Kamalakidis et al.[25] utilized both subjective evaluations (OHIP-20, satisfaction questionnaire) and objective evaluations (number of adjustment visits, total number of sore spots), to compare CDs fabricated with a traditional and a duplication construction protocol. They concluded, after a follow-up period of 6 months that the patients preferred their new prostheses irrespective of the construction protocol.

In a prospective clinical study that also compared CDs fabricated with a traditional and a duplication protocol, Ellis et al.[24] found no difference in patients' preference between the two construction protocols after a follow-up period of one month. Finally, Scott et al.[23] utilized the OHIP-14 instrument and a satisfaction questionnaire to determine the patients' preference after three months. They concluded that CDs fabricated with the duplication construction and the traditional construction protocols were equally accepted.

Table 2. Summary of studies assessing complete dentures' occlusal schemes.

Study (year)	Study design	Sample size (n)	Occlusal schemes	Variables (instruments)	Follow-up (months)	Patients' preference
Kawai et al[42] (2017)	RCT	60	BBO vs LO	OHIP-16, satisfaction	Baseline, 3 m, 6 m	No difference
Niwatcharoenchaikul et al[40] (2014)	PCS	10	BBO vs LO	Masticatory performance, max. occl. force	Baseline, 2 m,	Not applicable clinical evaluation
Shirani et al[39] (2014)	RCT-CO	15	BBO vs LO	OHIP-EDENT	1,5 m	LO
Deniz et al[38] (2013)	RCT	30	BBO vs LO	Electromyography, satisfaction	Baseline, 3 m, 6 m	LO
Matsumaru[37] (2010)	RCT	22	BBO vs LO	Masticatory performance, max. occl. force	Baseline, 3 m, 6 m	Not applicable clinical evaluation
Sutton et al[34,35] (2007)	RCT-CO	45	BBO vs LO	OHIP-20	2 m	No difference
Kimoto et al[36] (2006)	PCS	28	BBO vs LO	Satisfaction, masticatory performance, # of adjustments	2 m	LO
Sutton et al[34,35] (2007)	RCT-CO	45	BBO and LO vs MO	OHIP-20	2 m	BBO and LO
Schierz et al[33] (2016)	RCT-CO	19	CG vs BBO	OHIP-EDENT, OHIP-49	3 m	No difference
Paleari et al[32] (2012)	RCT-CO	44	CG vs BBO	Satisfaction, kinesiography	1 m, 2 m	No difference
Neto et al[31] (2010)	RCT-CO	24	CG vs BBO	Satisfaction, masticatory performance	3 m, 6 m	No difference
Rehmann et al[30] (2008)	PCS-CO	38	CG vs BBO	Satisfaction	2 weeks, 1 m	BBO
Peroz et al[29] (2003)	RCT-CO	22	CG vs BBO	Satisfaction, clinical evaluation	Baseline, 1 week, 1 m, 2 m, 3 m	CG
Heydecke et al[41] (2007)	RCT-CO	20	CG vs LO	Satisfaction	3 m, 6 m	No difference
Schierz et al[33] (2016)	RCT-CO	19	CG vs BBO	OHIP-EDENT, OHIP-49	3 m	No difference
Paleari et al[32] (2012)	RCT-CO	44	CG vs BBO	Satisfaction, kinesiography	1 m, 2 m	No difference
Neto et al[31] (2010)	RCT-CO	24	CG vs BBO	Satisfaction, masticatory performance	3 m, 6 m	No difference
Rehmann et al[30] (2008)	PCS-CO	38	CG vs BBO	Satisfaction	2 weeks, 1 m	BBO
Peroz et al[29] (2003)	RCT-CO	22	CG vs BBO	Satisfaction, clinical evaluation	Baseline, 1 week, 1 m, 2 m, 3 m	CG
Heydecke et al[41] (2007)	RCT-CO	20	CG vs LO	Satisfaction	3 m, 6 m	No difference

RCT: randomized clinical trial, CO: cross-over, PCS: prospective clinical study, BBO: bilateral balanced occlusion, LO: lingualized occlusion, MO: monoplane occlusion

Occlusal designs

The studies which addressed occlusal designs were divided into two main groups (Table 2). The first group compared different designs of balanced occlusal schemes: bilateral balanced occlusion (BBO), lingualized occlusion (LO) and monoplane occlusion (MO) and the second group compared balanced and non-balanced (canine-guided occlusion) occlusal designs.

In relation to posterior tooth set-up, the search identified eight articles[34–40,42] which involved seven studies. All studies compared a bilateral balanced occlusal design with a lingualized occlusal scheme. Two studies[34,35] included a comparison between bilateral balanced occlusal schemes (BBO and LO) and a MO. A double blind randomized clinical trial[42] used subjective evaluation instruments to assess patients' preference between a BBO and a LO design and concluded that there was no difference. The same conclusion was reached in RCT with a cross-over design, which resulted into two published papers[34,35]. The authors used the OHIP-20 instrument to subjectively evaluate patients' preference between CDs with a BBO, a LO and a MO scheme. It must be noted that when a comparison was made between BBO and LO versus MO, the patients preferred the BBO and LO designs.

On the contrary, three studies; an RCT with cross-over design[39], a second RCT[38] and a prospective clinical trial[36] concluded that a LO design rated superior in patients' preference over a BBO design. Those studies utilized objective and subjective evaluation criteria including masticatory performance, with follow-up periods ranging from six weeks to six months. Further on, after an objective evaluation in an RCT by Matsumaru[37], it was concluded that a LO was more efficient in terms of masticatory performance when compared with a BBO.

Regarding canine-guided (CG) occlusal design, five studies[29–33] were identified that compared CG with BBO and one study[41] which compared CG with LO. Three RCTs[31–33] with a cross-over design concluded that there was no difference in patients' preference between the two occlusal designs. They utilized both subjective and objective assessment criteria over a one to six month follow-up period. Rehmann et al.[30] in a prospective clinical trial concluded that patients preferred a BBO to a CG design over two week follow up period. On the contrary, in a cross-over RCT by Peroz et al.[29], it was concluded that dentures with a CG occlusal design were more satisfying to the patients over a BBO. Finally, Heydecke et al.[41] conducted the only study that compared a CG occlusion to a LO. They utilized subjective evaluation criteria in the form of a satisfaction questionnaire, over a three to six evaluation period. The results indicated that there was no difference in patients' preference between the two occlusal designs.

Discussion

The main focus of the authors for the current review was to assess the CDs construction protocols and occlusal designs from the patients' perspective. It has been established that the patients' subjective evaluation criteria were different than the objective criteria used by the dental professionals.[45] In order to achieve the highest level of evidence, only randomized clinical trials and well designed clinical studies were included. Statistical analysis and comparisons between the studies was not possible due to the limited number and heterogeneity of the included studies.

Regarding CDs construction protocols, it has been speculated that the simplification of the clinical and laboratory stages would not have a significantly negative effect on the overall denture quality[7]. Based on the four available studies[11–17], that assumption could be granted a secure basis, since all of them revealed no difference in the general patients' preference between dentures constructed either with a simplified or a traditional protocol. It must be noted that in the study by Heydecke et al.[17], although the general satisfaction item scores favored the simplified protocol (p=.044), five out of eight items were in favor of the traditional protocol. When the simplified and the traditional construction protocols were assessed on the basis of total costs and fabrication time, two studies[12,16] concluded that CDs fabricated with a simplified protocol cost between 23% and 33.6% less and that the required fabrication time was 4 visits compared to 5-6 visits of the traditional construction protocols.

The subject of CAD/CAM fabricated CDs has compiled limited number of studies which focused on the clinical outcomes of the construction process. Two non-randomized clinical studies[20,21] compared CAD/CAM dentures to CDs fabricated with a traditional protocol. Only Kattadiyil et al.[20] subjectively evaluated the patients' preferences with a five point Likert scale and reported an 80% satisfaction preference for the CAD/CAM prostheses with a LO scheme. Additionally, one of the main advantages of the CAD/CAM dentures that of the reduced number of appointments, was still debated since Kattadiyil et al.[20] reported the need for two visits until the denture delivery, while Schwindling et al.[21] reported that they needed a mean number of 5.4 visits.

Duplication of existing complete dentures, as part of a replacement denture construction protocol, has been an alternative denture fabrication technique. Three prospective clinical studies[23–25] compared CDs constructed with a duplication protocol to CDs with a traditional construction protocol. No significant differences could be detected in all studies regarding patients' preference, a fact that could be attributed to the strict adherence to each construction protocol since all of the studies were set at an academic environment. Kamalakidis et al[25] also recorded the total number of

sore spots, which were almost half for the duplication construction protocol. This finding could suggest that a duplication construction protocol might provide a better solution for geriatric patients with poor neuromuscular control and severe bone resorption, who require a more comfortable adaptation with fewer sore spots.

Complete denture balanced occlusion could be provided by means of BBO and LO. The authors identified five randomized clinical trials[34,35,37–39,42] and two prospective clinical studies[36,40] that compared those two occlusal designs. Those studies used subjective and objecting criteria to determine patients' preference and they concluded that there were no significant differences between the two occlusal schemes. Additionally, in three studies[36,38,39] it was concluded that LO was preferred by the patients over BBO in terms of masticatory ability and performance. This finding was positively correlated with the height of the residual ridge, strengthening the belief that patients with severe residual ridge resorption might benefit from the occlusal design of LO. Further on, when CDs with monoplane occlusion were compared with bilateral balanced and lingualized occlusal schemes, the patients strongly preferred the latter on the basis of esthetics and food comminution[34,35].

One of the dogmas in removable prosthodontics has been the concept of bilateral balance occlusion. It has always been a subject of debate as to whether we need to provide our patients with simultaneous posterior contacts in centric and eccentric movements, while at the same time they try to balance the food bolus during masticatory movements. Contemporary views on the topic of complete denture occlusion have led to the introduction of non-balanced occlusal schemes as an alternative to balanced occlusal designs. The current review identified four RCTs[29,31–33] with a cross-over design that compared BBO versus CG. Only one of those studies, by Peroz et al.[29], established that CG was preferred by the patients with relation to esthetics, mandibular retention and chewing ability. It must be pointed out that the topic of CG for complete dentures needs further investigation and has to be correlated with the anatomy of the mandibular residual ridge of individual patients in order to reach safe recommendation guidelines for future clinical applications.

Conclusions

Within the limitations of this review the following conclusions could be drawn: (a) Patients adapt to all construction methods when strict adherence to the protocol is observed. The simplified construction protocols may offer reduced costs and fabrication periods, (b) Patients adapt comfortably to any design of bilateral balance occlusal scheme. Lingualized occlusion provides better stability and masticatory performance in patients with severely resorbed residual ridges, (c) Disease-specific questionnaires should be used to assess the outcome of any treatment modality.

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