



Review Article

Maintaining occlusal stability by selecting the most appropriate occlusal scheme in complete removable prosthesis

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ABSTRACT

The search of an adequate occlusal scheme that maximizes dentures' stability and patients' satisfaction is an ultimate objective in every complete prosthodontic treatment. Many studies compared occlusal schemes in terms of retention, comfort and masticatory performance. The purpose of this article is to review literature about different occlusal schemes related to complete dentures' stability and edentulous patients' satisfaction, in order to select the most appropriate occlusal scheme. Thus, an electronic search was performed from PubMed (MEDLINE), Scopus, Cochrane, Google Scholar and Sciencedirect databases. 65 articles were identified of which 56 were selected to compose the present article. Within the limitations of this review, it has been concluded that edentulous patients prefer anatomic occlusal schemes to non-anatomic teeth. Furthermore, canine guidance seems to be efficacious in terms of chewing comfort and dentures' retention, as well as lingualized occlusion. However, bilateral balanced occlusion does not confer a long-term masticatory performance and satisfaction to edentulous patients.

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1. Introduction

Edentulism alters patients' function, esthetics, phonation and psychology. It is considered as a globally important health issue for its high prevalence which exceeds 10% in adults aged more than or equal to 50 years, furthermore, this rate tends to be higher in developed countries [1,2]. Although dental implants showed a great progress in complete rehabilitation, the demand for conventional prosthodontic treatment is still high, due to physiological, surgical, economical and psychological limitations.

Patients' dissatisfaction with removable complete dentures is essentially related to loss of retention (85,9%) [3,4]. Furthermore, it has been found that a clinically stable mandibular denture was the most important determinant of patients' satisfaction [5–7].

Several studies have pointed out the importance of occlusal scheme for achieving denture retention and patients' satisfaction [8–10]. For Lang et al. (2004) the most important factor that contributes to stability are the occlusal scheme and occlusal harmony [11]. Moreover, According to the list of old and current dogmas

in prosthodontics presented by Carlsson in 2009, there is an “old” truth about bilateral balanced occlusal (BO) scheme, which is held by so many prosthodontists as fundamental to create stability [12].

Thus, the purpose of this article is to review the literature about various occlusal concepts and designs, and to define their advantages and disadvantages, in order to select the best occlusal scheme for every situation to keep occlusal stability and patients' satisfaction in long term.

2. Materials and methods

A comprehensive literature researches were performed in the Pubmed (MEDLINE), Scopus, Cochrane, Sciencedirect and google scholar databases, published before July 2018. The following Keywords were used: Occlusal stability, Patients' satisfaction, occlusal schemes, masticatory performance. Searches were also performed from the references figuring in the articles selected in advance. Studies have been selected based on title, abstract, material and methods. The minimum inclusion requirements were (1) randomized controlled trials, (2) systematic reviews, (3) prospective studies. Studies that did not meet the inclusion criteria, in vivo studies and all article related to implants and partial dentures were excluded.

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3. Results and discussions

3.1. Occlusal schemes in complete removable prosthesis

Occlusal schemes in complete removable prosthesis are defined as the form and the arrangement of the occlusal contacts in artificial dentures [13]. They have been classified into:

- Neurocentric occlusion (NCO).
- Lingualized occlusion (LO).
- Non-anatomic occlusion (monoplane occlusion with balance).
- Balanced occlusion (BO).
- Canine guidance occlusion (CG).

3.1.1. Neurocentric occlusion [11,14,15]

That concept has been established by DE VAN in 1954. It is characterized by posterior teeth presenting flat planes in all directions with no medial or lateral inclination. That occlusal scheme required a parallelism of antero-posterior plane of occlusion with the plane of denture occlusion foundation.

Occlusal forces are directed toward posterior teeth, the center of support, by eliminating all antero-posterior or mediolateral inclinations.

3.1.1.1. Advantages [14,16].

- Simple technique, teeth are arranged in a NCO. So, it is easier to adjust them than anatomic teeth.
- It centralizes the masticatory force.
- It facilitates the obtention of accurate jaw relations. So, it is especially indicated in class II and class III.
- It generates less pressure transmission than cusped teeth.

3.1.1.2. Disadvantages [14,16].

- It is a unaesthetic occlusal scheme.
- Flat teeth may cause impaired mastication.

3.1.2. Lingualized occlusion

That concept was introduced first by Gysi in 1927. Gysi's scheme showed maxillary posterior featured single, linear cusps entering in contact with shallow mandibular depressions. However, artificial tooth choices in the era were very limited [17–19]. Later on, PAYNE in 1941 describes LO as the articulation of the maxillary palatal cusps with the mandibular occlusal surfaces, in centric and eccentric mandibular positions. He uses 30° degree tooth to attain the LO [18,20,21]. As time passed, some authors described that occlusion scheme using modified procedures and tooth forms [18]. As an example, Pound sets a LO similar to Payne's scheme. He combines maxillary cusp angles (>30°) with mandibular cusp angles (<20°) [22,23].

3.1.2.1. Advantages [21,24].

- Aesthetic and function are combined in that occlusal scheme.
- Mandibular teeth centralize vertical forces.
- Food bolus is well-penetrated.
- When bilateral balanced occlusion is used with LO, it accords more stability and a favorable stress distribution in parafunctional and excursive movements than single LO.

3.1.2.2. Disadvantages [21,25,26,24].

- When flat teeth are used in maxillary arch, the lingual occlusion seems unaesthetic.
- When using porcelain-porcelain teeth, the clicking sound during mastication may be disturbing for patients.

3.1.3. Monoplane occlusion

It required zero-degree or non-anatomic teeth, posterior denture teeth non anatomically formed, presenting zero-degree cuspal angles in relation to a flat occlusal plane established by the horizontal occlusal surface of the tooth [20].

3.1.3.1. Advantages [27–29].

- It gives a marge of freedom to patients since the mandible is not locked at a unique position.
- Horizontal forces are reduced, which cause, according to JONES, more damages than vertical ones.
- Flat teeth are useful in reducing stress in complete lower denture.
- Monoplane occlusion is more adaptable for class II and III malocclusions.

3.1.3.2. Disadvantages [21,30].

- Monoplane teeth are not esthetically accepted.
- Patients may complain from phonetics' troubles due to tooth display' insuffisance related to a zero-degree incisal guidance.
- Masticatory efficiency is decreased.

3.1.4. Balanced occlusion

The Glossary of Prosthodontic Terms defines BO as the bilateral, simultaneous, anterior and posterior occlusal contact of teeth in centric and eccentric positions [20].

3.1.4.1. Advantages [31–34].

- It preserves edentulous ridge from resorption and increases dentures' stability.
- It provides a great masticatory function since it brings sufficient grinding surfaces in contact at excursive movement.
- It facilitates patient's adaptation to new complete dentures.

3.1.4.2. Disadvantages.

- Changes in chewing pattern are required for denture wearers, which extends the period of adaptation to complete dentures [35–37].
- It requires a semi-adjustable or fully adjustable articulator [38].
- It may increase lateral and protrusive grinding habits [38].
- It is hard to realise in presence of an increased vertical incisor overlap [38].

3.1.5. Canine-guidance occlusion

According to the glossary of prosthodontic terms, CG scheme refers to complete dentures adjusted with mutually protected articulation in which the vertical and horizontal overlap of the canine teeth disengage the posterior teeth in the excursive movements of the mandible [20].

3.1.5.1. Advantages.

- It protects the occlusion from eccentric forces [39].
- It does not require a high muscle activity during lateral movement and protrusion [40].

3.1.5.2. Disadvantages.

- CG occlusal scheme in complete dentures is supposed to lead to considerable dislocations during eccentric movements [41].

3.2. Patients' satisfaction and occlusal schemes

3.2.1. BO vs LO

A prospective study has been realized by Kimoto et al. in 2006. The study includes 28 edentulous patients divided equally into two groups. The first group was treated by complete dentures fabricated using LO scheme. The second one was treated by complete dentures with BO. Two months after the post-insertion follow-up, we found that there is an ultimate correlation between complete dentures' retention and occlusal schemes. In addition, patients were more satisfied with LO in terms of masticatory performance and retention. However, in this study, there were three major limitations: First, a lack of randomization, second, a small sample size, and finally, a brief period of follow-up. So, more studies are needed in this regard to confirm these results [42].

Similarly, Deniz et al. in 2013 realized a study to analyse the influence of occlusal scheme on masticatory performance and edentulous patients' satisfaction. There were 2 sets of complete dentures for each patient. Thirty patients were treated by BO for 3 months, then LO during 3 months later according to a single-blind design. Electromyographic measurements were realized first at three months, then at 6 months. This study showed that muscles activity and masticatory performance were greater with LO compared to BO. So, patients were more satisfied wearing complete dentures with LO [43].

These results were also reported in another randomized clinical trial by Abdulrazzaq et al. (2016), who showed that LO attributes a better function and comfort in comparison with BO. However, this study may not be of a strong evidence since it includes only 60 patients followed-up during a brief period of 1 month [44].

In accordance with these findings, a recent study realized by Kawai et al. (2017) showed that LO is preferred in terms of satisfaction for complete edentulous with resorbed mandibular alveolar ridge. That study includes 60 participants who were randomly divided into two groups. 30 patients were provided complete dentures with LO, and the others were treated by complete denture with BO. The study's follow-up was 6 months. In spite of the limited number of participants and follow-up time, these findings confirm that patients are satisfied and feel more comfortable with LO in comparison with BO [45]. It appears that this preference might be a consequence of the technical arrangement of both of LO and BO. Molar contacts are simply arranged and adjusted in LO compared to BO, in which are considered technically more complicated [45].

Furthermore, Matsumari in 2010 conducted a randomized clinical trial to analyse the influence of mandibular residual ridge on masticatory performance using two occlusal schemes: LO and BO. 22 Participants were assessed 1 set of complete dentures with either LO or BO. Masticatory performance and mandibular movements were measured at 3 months and 6 months follow-ups. It has been reported that patients with BO developed a significant decrease in the masticatory performance, in addition to an increasing in linear inferior deviation from intercuspal position at 3 months, as well as an increasing in the linear posterior and inferior deviation from intercuspal position at 6 months. Patients with BO losted approximately complete dentures' stability and retention. To sum up, LO is greater than BO in terms of masticatory performance and mandibular movements for patients with severely mandibular residual ridge [46].

To confirm these findings, a recent study realized by Farias-Neto et al. (2015) demonstrated a decrease in pain and an improvement

in fit of the mandibular dentures observed, in general, between 3 and 6 months. In some cases, a period of 6 and 8 weeks may be sufficient for patients to develop a muscle adaptation to functional activities and a better masticatory performance, exceptionally, some patients may need more time to get adapted to their new dentures [47]. However, more studies including an important number of participants with mandibular alveolar resorbed ridge and a long duration of follow-up are needed to confirm these findings.

By contrast, another study conducted by Butt et al. (2016) revealed that BO confers a higher masticatory efficiency and comfort compared to LO. However, in this randomized clinical trial, the follow-up of the 60 participants was only 1 month, that may could influenced negatively these findings [48].

Overall, these results suggest that LO is preferred by edentulous patients in terms of masticatory performance and satisfaction.

3.2.2. Anatomic vs non-anatomic occlusion

In 1999, Ohguri et al. conducted a study to evaluate the influence of occlusal scheme on occlusal force needed while crushing soft food or carrot. That study demonstrate that BO and LO schemes requires less occlusal force compared to monoplane occlusion. Moreover, the stress transmitted to the supporting tissues in case of BO and LO is lesser than with monoplane occlusion [49].

A recent randomized cross-over trial has been realized by Sutton et al. in 2007 to compare edentulous patients satisfaction with zero-degree (ZDO), anatomic, and LO schemes. That study included 45 participants who were provided by 3 sets of complete dentures, realized according to the 3 occlusal schemes pre-cited. Patients wore randomly each set for a period of 8 weeks. It has been reported that patients were more satisfied with LO and anatomic posterior occlusal schemes than ZDO. However, more studies with a long period of follow-up are needed to confirm these results [50,51].

3.2.3. BO vs CG

In 2003, a randomized clinical trial was conducted by Peroz et al. in order to evaluate BO compared to canine guidance occlusal scheme. In that study, 22 patients were treated using 2 complete dentures with 2 occlusal schemes. One half of the participants were at first given CG dentures, or BO, respectively. After that, follow-up examinations were realized after 8 days, 4 weeks, 8 weeks, and 3 months, to check patients' satisfaction with esthetic appearance, chewing and speaking ability and dentures' retention. After that period, the occlusal scheme was changed. Researchers found that CG occlusal scheme is better than bilateral occlusal scheme in terms of patients' appearance satisfaction, mandibular denture retention and chewing ability [9]. However, due to the small number of participants, and the repetitive follow-up examinations which might have not been respected by some patients, we need more studies with a strong evidence to support these findings.

Similarly, a recent double-blinded controlled crossover clinical trial was conducted by Farias-Neto et al. in 2010 to study the maintenance of masticatory efficiency in complete denture wearers with the same occlusal schemes: BO and CG. The study included 24 participants who wore sets of complete dentures with both occlusal schemes during an equal period of three months. This study reveals also that BO scheme does not improve masticatory efficiency compared with CG design [52].

Recently, Another study was conducted in 2012 by Paleari to analyse the influence of the same occlusal schemes on denture satisfaction and kinesigraphic parameters. That study includes 50 patients from whom 44 participants received randomly two complete dentures with CG and BO. All participants presented a normal volume of residual ridges. Then, each occlusal scheme was tested during 30 days. A denture satisfaction questionnaire was applied, and a kinesigraphic instrument was recorded to test physiologic movements during chewing. This study showed

Table 1
Patients' satisfaction with different occlusal schemes.

Authors	Study-type	Patients, occlusal schemes related and follow-up	Findings	Conclusion
Kimoto et al. (2006) [42]	Prospective comparative trial	28 LO (14) BO (14) 2 months	- Patients with LO are more satisfied with their dentures retention than those having BO.	- There is a correlation between complete dentures' retention and occlusal schemes. - Patients are more satisfied with LO in terms of masticatory performance and retention.
Deniz et al. (2013) [43]	Prospective study	30 BO (30) LO (30) 3 months for each set	- Muscles activity and masticatory performance were greater with LO compared to BO.	- LO exhibited more satisfaction and comfort compared to BO.
Abdulrazzaq et al. (2013) [44]	RCT	60 LO (30) BO (30) 1 month	Patients reported a greater masticatory performance and comfort with LO in comparison with BO. - No significant differences were noted between BO and LO.	- LO showed a better function and comfort compared to BO.
Kawai et al. (2017) [45]	A double blind RCT	60 LO (30) BO (30) 6 months	- At 6 months, Participants with BO mandibular dentures showed a lower satisfaction. - BO developed a significant decrease in the masticatory performance.	- LO is preferred in term of satisfaction for sub-groups with resorbed mandibular alveolar ridge.
Matsumari et al. (2010) [46]	RCT	22 LO (22) BO (22) 3 months 6 months	- BO showed an increasing in linear posterior and inferior deviation from intercuspal position.	- LO is greater than BO in term of masticatory performance and mandibular movements for patients with severely mandibular residual ridge.
Butt et al. (2016) [48]	RCT	60 LO (30) BO (30) 41	- Patients with BO were able to masticate with comfort and ease in comparison with those with LO.	- BO confers a high masticatory efficiency and comfort compared to LO.
Sutton et al. (2007) [50,51]	RCT	BO (41) LO (41) ZDO (41) 8 weeks for each set	- LO and BO were significantly better than ZDO in terms of chewing and eating ability, in addition to stability and appearance.	- Patients were more satisfied with LO and BO compared to ZDO.
Peroz et al. (2003) [9]	RCT	22 BO (10) CG (12) 8 days, 4 weeks, 8 weeks, and 3 months	- Patients were more satisfied and feel comfortable with CG since it provides better retention, chewing ability and esthetic appearance.	- CG is better than BO in terms of patients' appearance satisfaction, mandibular denture retention and chewing ability.
Farias Neto et al. (2010) [47]	RCT	24 BBO (24) CG (24) 3 months for each set	No significant differences were noted between BO and CG.	BO does not improve masticatory efficiency compared with CG.
Paleari et al. (2012) [53]	RCT	44 BBO (22) CG (22) 1 month for each set	No significant differences were detected between BO and CG.	Occlusal scheme did not influence patients' satisfaction.
Shierz et al. (2016) [54]	RCT	15 BO (15) CG (15) 3 months for each set	Patients' perception and oral health quality of life were comparable for both BO and CG.	No statistical or clinical difference between BO and CG.
Rehmann et al. (2008) [33]	Prospective	38 BO (38) CG (38) 2 weeks 4 weeks	Patients were more satisfied with BO than CG.	BO facilitates the adaptation at the initial phase after fitting new complete dentures
Niwatcharo-enchaiikul et al. (2014) [56]	Prospective	10 BO (10) NO (10) 20	No difference was noted between occlusal schemes for masticatory performance and maximum occlusal scheme.	Occlusal schemes did not influence on masticatory performance and maximum occlusal scheme.
Heydecke et al. (2007) [57]	Cross-over trial	CG (20) LO (20) 3 months for each set	Chewing ability was significantly better with CG compared to LO.	Patients' satisfaction increased significantly with CG.

that occlusal scheme did not influence patients' satisfaction and kinesiographic parameters since the volume of residual ridges of edentulous patients was normal. However, more studies are needed in that area, including edentulous patients with normal and resorbed alveolar ridges to confirm these findings [53].

In the same context, Shierz et al. (2016) compared the effect of two occlusal schemes, CG vs BO, on oral health quality of life of 19 edentulous patients. In this randomized single-blind cross-over trial, participants were treated by new maxillary and mandibular complete dentures. At first, their prosthesis were designed according to one of the two occlusal schemes. After three months, their complete dentures were adjusted with the alternative occlusal scheme. The second follow-up was scheduled at 3 months again. As a result, for both occlusal schemes, patients' perception were comparable, moreover, there was no statistical or clinical difference on oral health quality of life of these patients [54]. In spite of the randomization of this single blind study, it presents some limitations like the restricted sample size, the lack of informations about the high of alveolar ridges, the duration of edentulism and the age of preexisting complete dentures [54].

On the other hand, Rehmann et al. in 2008 realized a clinical single blind study to evaluate patients' satisfaction with complete dentures. This study includes 38 patients who were given 1 maxillary complete denture and 2 mandibular complete dentures, with two occlusal schemes: BO, and CG. Participants have been controlled at 2 and 4 weeks. Authors reported that BO facilitates the adaptation at the initial phase after fitting new complete dentures [33]. In the same context, some previous studies reported that after the initial phase of the insertion of new dentures, balancing contacts are no longer present due to acrylic tooth wear and changes in supporting tissues [55]. So, more studies are needed to evaluate these findings in long-term after the insertion of the prosthesis.

To sum, it appears that edentulous patients are more satisfied and comfortable with CG occlusal scheme than BO. However, additional randomized studies are needed with a large number of participants, and more details about clinical examinations to support these findings.

3.2.4. BO vs NCO

To evaluate masticatory performance and maximum occlusal forces for BO and NCO, Niwatcharoenchaiikul et al. in 2014 conducted a study on 10 edentulous participants, using the interchangeable teeth technique that removed the maxillary and mandibular posterior teeth, only anterior teeth were left on the trial bases. As a result, no difference was noted between occlusal schemes for masticatory performance and maximum occlusal scheme. However, better masticatory performance was noted when number of chewing strokes was increased for both occlusal schemes. Although, other studies using subjective methods are needed to confirm these findings [56].

3.2.5. CG vs LO

In a cross-over trial realized by Heydecke et al. in 2007, 20 edentulous patients were given two sets of complete dentures with two occlusal schemes: CG with anatomic-teeth and LO scheme with semi-anatomic teeth. Each pair of the dentures was worn for 3 months post-receiving, in a randomized order. Results showed that chewing ability was significantly better with CG occlusal scheme compared to LO. So, patients' satisfaction increased significantly with that occlusal concept [57].

In conclusion, within the limitations of the articles included above, results suggest that some occlusal schemes like CG and LO are implicated in patients' comfort and satisfaction, their effects is better than BO (Table 1). However, most of the studies represented a brief period of follow-up which might have affected the results, since the neuromusculoarticular adaptation period of the

prosthesis had not been attempted. Furthermore, most of the studies did not take into consideration some factors like the duration of edentulism, the high and the form of alveolar ridges. So further investigations are needed to determine the appropriate occlusal scheme for every edentulous patient.

4. Conclusion

According to the articles included in this review, it is clear that patients are more satisfied with occlusal schemes using anatomic teeth than with monoplane occlusion.

Furthermore, CG occlusion is reported to be satisfactory in the fabrication of complete dentures. LO can be also used successfully, whereas, BO might be less satisfactory than CG and LO, contrary to what have been reported in the literature for many years.

To sum, it is evident that edentulous patients' satisfaction with complete dentures is clinically determined by stability, which is related to the occlusal scheme. Thus, it is suggested to take into consideration some characteristics like: Age, muscular and parafunctional activity, height and width of residual ridges, psychological and aesthetic factors, in order to achieve a considerable dentures' stability. Basing on those informations, the prosthodontist would be able to select the most appropriate occlusal scheme when two or three concepts might be adequate.

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Conflict of interest

The authors declare that they have no conflict of interest.

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