Specific biomechanical and clinical issues of removable partial dentures: literature review

Špecifické biomechanické a klinické problémy so snímateľnými čiastočnými náhradami: prehľad literatúry

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Abstract
Review of possible modifications of partial denture connection elements and specific risks of their clinical use remains relevant issues of modern dentistry that argument the need for further detailed research. The available database of scientific papers allows not only to provide retrospective review of prior research and trials with formulation of appropriate conclusions regarding specific planning of orthopedic treatment with the use of partial dentures, but also helps to develop specific recommendations for the evaluation and prediction the parameters of clinical efficacy of such prosthetic structures.

Key words: partial removable dentures, retention, denture design.

Abstrakt
Prehľad možných modifikácií spojovacích prvkov čiastočnej náhrady a špecifické riziká ich klinického využitia zostávajú dôležitou problematikou moderného zubného lekárstva, ktoré zdôrazňuje potrebu ďalšieho podrobného výskumu. Dostupná databáza vedeckých prác poskytuje nielen retrospektívny prehľad predošlých výskumov a pokusov, s naformulovaním vhodných záverov s ohľadom na konkrétne plánovanie ortopedickej liečby s použitím čiastočných zubných náhrad, ale tiež pomáha vypracovať konkrétne odporúčania pre zhodnotenie a predikciu parametrov klinickej účinnosti takýchto protetických štruktúr.

Kľúčové slová: čiastočné snímateľné náhrady, strojček na zuby, dizajn zubnej náhrady.

Introduction

The use of removable partial dentures provides an effective replacement of dentition defect with a possibility for functional balanced relationship restoration between constituent elements of the teeth-jaw complex system [3, 7]. The prevalence of dental implants treatment designs and different protocols of their loading justified by sufficient amount of evidence-based data, but financial accessibility of such rehabilitation algorithm continues to be limited among general population [22, 27-29]. Modification of partial dentures designs helps to improve the parameters of their functional stability and retention, and the tendency of modern computer milling processes assists in achieving precise prosthetic components that would perfectly fit into the available clinical conditions [15, 18, 20]. On the other hand, partial dentures characterized by appropriate risk of different complications such as changes in supporting teeth inclination due to the corresponding denture's occlusal schemes,

increasing natural teeth mobility, compromentation of periodontal status, changes in bone density [7]. Therefore, review of possible modifications of denture connection elements and specific risks of their clinical use remains relevant issues of modern dentistry that argument the need for further detailed research. The available database of scientific papers allows not only to provide retrospective review of prior research and trials with formulation of appropriate conclusions regarding specific planning of orthopedic treatment with the use of partial dentures, but also helps to develop specific recommendations for the evaluation and prediction the parameters of clinical efficacy of such prosthetic structures.

Objective: to conduct a retrospective analysis of scientific publications with the aim of identification key features of prevalent removable partial dentures designs in the dental practice; establish the possibility of modifying existing retention elements and their impact on the stability of partial removable dentures; summarize the prospects of partial dentures in prosthodontics practice.

Materials and methods. Retrospective analysis of scientific publications has been implemented within Google Scholar search system. The sample of studied materials was formed based on the results of keywords search. Analysis of selected publications provided using the method of content analysis, principles of quantitative and qualitative processing of text materials, followed by interpretation and grouping of obtained results. Systematization of analyzed data was performed using the principle of analytical results grouping and use of Microsoft Excel software (Microsoft Office, 2013), which helped to carry out the distribution of numerical data taken from prior analyzed scientific publications.

Results and discussion. Implementation of modern CAD & RP and CAD / CAM technology helps to individualize the prosthetic possibilities among dental patients with complete and partial edentulism using various types of denture structures, including removable [26]. Development and modification of different approaches of prototyping helps not only to strengthen dentures design, but also to adapt it to the different clinical conditions of oral cavity among patients with different baseline clinical features (atrophy, the number of abutment teeth, condition of mucosa, occlusion ratio). Although the cost of such treatments is still relatively high, but the time savings and precision performed designs justify the financial costs in the long term perspective functioning of prosthetic restorations [14]. Kattadiyil M.T. and colleagues (2014) also noted that the future trend of partial removable framework fabrication bases on the wide use of intraoral scanning possibilities, whereas before, the vast number of published clinical cases and technical reports was dedicated to the extraoral scanning capabilities of cast models [11].

De Baat et al. (2010) provided the research aimed to evaluate occlusion parameters and temporomandibular joint function changes promoted by distal extension of removable partial dentures [5]. Authors revealed that this approach of optimization retention parameters of dentures does not cause changes in joint function, but not among those providing almost no gain in occlusal interaction. Research design included patients sample with parafunctional changes that manifested equally for all designs of different dentures, such as removable full, removable partial and removable partial dentures with distal extension. Similarly, in all study groups authors notified abnormal abrasion of lower frontal teeth, while in premolar region was registered even higher level of abrasion due to the change of occlusal relationships.

Rodrigues et al. (2013) compared the degree of retention and load distribution during the use of three different types of semi-removable designs: classic partially removable dentures, their analogs with the implant and healing abutment, and analogs of dentures with the use of implants and O-ring attachments (implant insertion was provided at the distal areas of jaws) [23]. The results of study had shown that use of implants helps to adjust the chewing load transmission between the supporting units and dentures, and the use of O-ring attachment between partial dentures and implant improves the distribution of the forces due to their partial adsorption by the matrix-site connectors. The retention strength of classic partial denture with distal extension and those with semi-implant support was differed by 0.7-0.9 N after 5 years of functioning, although the most significant difference of retention strength was observed at the period of 6 months and 1 year. Argumentation of using various reinforcing elements inside partial dentures structures has also been described in studies of Jiao et al. (2009) [8]. During their

research they found that in experimental conditions, the greatest amount of stress in the area of vital tooth among different designs of dentures was observed using fully polyacetal construction that provoke the concentration of the highest stress is in the supporting teeth and bone. Dentures, which were reinforced with metal parts and with elements of connection (arc or clasps) passed the stress on the bone through the supporting teeth and more evenly provoke peak stress values in certain anatomical areas. Thus, taking into account also the aesthetic dimension authors suggested that the use of hybrid prosthesis design that combines a metal frame, plastic base and polyacetal clasp ensure comprehensive rehabilitation of dental patients with partial aedentia. Saito and Miura (2003) compared the stability parameters of partial dentures with different retention elements and came to the conclusion that stress occurred in the region of latter abutment tooth with precise attachments or telescopic crowns is greater than that stress occurred in the area of final clasps [24]. In turn, shift of denture base can be minimized by tighter attachment and cross-arched stabilization. In some clinical situations to provide support of partial removable dentures dentists have to initiate periodontal splinting teeth of compromised residual dentition units. That is one of the ways to ensure a more predictable outcome of occlusal schemes function and stabilization of patient's status. Geramy (2010) devoted his research to this question using finite element methods and found out that the splinting of teeth, that provide support for the partial denture, helps to achieve even load transmission from crestal to apical region in cases of periodontally compromised dentition, but the distribution of stress between two teeth (premolars in the case study) was not uniform considering different initial degree of mobility [6]. So, we can conclude that the splinting of weak supporting units in such clinical cases is not always substantiated. Akaltan and Kaynak (2005) during clinical monitoring of patients found that the use of structural lingual plate in denture construction helps to reduce mobility of teeth that were mobile before, thus helping to improve the comprehensive dental periodontal status of patients [1].

In order to find out the objective intraoral parameters of masticatory load transmission Kubo and Kewata (2008) proposed to use the I-SCAN device, which is a kind of tactile sensor [13]. Authors study design was called to registrate changes in different elements of partial removable structures that displaced denture defect (Class 1 Subclass 2 by Kennedy). As a result, researchers confirmed classic statement that the distribution of masticatory load through the denture defined by the direction of applied force and outer contour (shape) of residual crest. As for the lateral load distribution various studies show different results: some argue that the significant denture migration under load influence occurs during force direction on the lingual side, the others - on the buccal side. Obviously, the role of forming displacement vector determined by the shape of alveolar crest, occlusion pattern of the patient, usual motion pattern of the jaw during chewing process, and even by the morphology of the artificial teeth. In addition, during chewing the gum authors found negligible migration of load transfer centers, that obviously, is based on specifics of mastification cycle and offset of occlusal point during the formation different types of contacts. Kawata (2008) propose to use piezoelectric transducer for the 3-dimensional distribution analysis of masticatory forces at the abutment tooth during the fit of partial removable denture and without latter [12]. Author found that there was no significant difference in load distribution, and the influence of supporting denture elements only contributes for the better distribution of masticatory load on the tooth, if they placed frontal to the extended denture base. Thus, the use of reasonable construction of partial dentures contributes to a better distribution of the forces within the abutment tooth, which in turn improves the prognosis of its clinical performance.

Petridis and Hempton (2001) conducted a study of the effect of partial dentures on the level of oral hygiene, because various previous studies have tended to show the increase of plaque accumulation during the functioning of such type of denture [21]. According to the authors partial dentures did not provoke adverse periodontal reactions and achievement of appropriate level of oral hygiene during pretreatment preparation of oral cavity and ensure its stability while using removable dentures did not initiate reduction of any hygienic parameters that were observed in the study. Other authors indicated that the partial denture design affects not only the biomechanical features of its function, but also the level of plaque accumulation in different parts of prosthetic construction [19].

The original study of Lyons (2005) that was conducted by the simulation of the replacement

resection maxillary defect with the partial dentures found that such prosthetic protocol provokes inclination increase of teeth adjacent to the defect [16]. The value of such inclination correlated with an increase of defect size, and splinting of teeth promoted more equitable distribution of masticatory load, which in turn contributes for the more efficient clinical prognosis of teeth as supporting units. The problem of increased mobility of abutment teeth within removable partial dentures remains an important issues of modern prosthetic dentistry, as the risk of compromised periodontal status of abutment teeth predicts success parameters of overall treatment success. In contrast to this statement, Jorge and colleagues (2007) conducted dedicated to the registration of mobility changes among teeth that supported partial dentures with the use of Periotest device [10]. The analysis of 68 teeth could not detect any statistically significant changes in their mobility while supporting partial dentures during 1, 3 and 6 months after the fixation of removable prosthetic structure. Support of adequate oral hygiene and optimal planning of all treatment stages improves prognosed efficiency of removable partial constructions.

Mizuuchi (2002) during analysis found that the design of retainer more significally affects the formation of the corresponding force shift, rather than direction of a specific vector displacement itself [17]. It was also noticed that the distal displacement of abutment tooth was significantly less in Type M clasp (with mesial rest and connection) than in Type D clasp (with distal rest and connection). On the other hand, denture displacement is more influenced by the localization of applied forces points, that defines the deflection of abutment teeth and their inclination vector, such as lingual or posterior load on the denture provokes projected distal displacement of the supporting units.

Nishiyama (2004) found out that denture design itself increasingly influence shift direction of abutment teeth, and the degree of such displacement is greater in dentures with unilateral design than within bilateral construction [9]. The researchers found out that ending the denture teeth at the mesial cusp of second molar and positioning the occlusal contacts over the ridge crest adequately stabilize the abutment tooth and denture base structures within unilateral partial dentures. Sato (2003) [25] was learning opportunities to achieve greater stabilization of the prosthesis, by modifying buccolingual width and position occlusal rest seats, as a result of the research found that buccal shifting of the rest seats seems to be advantageous for load transmission to the abutments. From this three important consequences were also established: for buccal loading, the wide rests and the buccal-shift rests produced lower tensile forces at the indirect retainer; for lingual loading, buccal-shift rests produced the lowest compressive force to the anterior abutment for the direct retainer; for the tooth-supported RPDs analyzed, buccal shifting of the rests was advantageous in load transmission to the abutments. So, based on the author originally developed three-dimensional geometric model analysis, it can be argued that taking into account the basic biomechanical principles promotes individualization of dentures design and minimize the risk of further biological complications during its prospective functioning.

Cosme (2006) [4] during the investigation of clinical and functional effectiveness of partial dentures after 5 years of their functioning among group of 50 patients, found that the result of such construction use, in most cases was classified by patients as excellent or good. The author noted that the evaluation of prosthetic rehabilitation results should take in the account not only patient's subjective assessment, but must carry out its correlation with clinical examination data provided by dentist. Typically, such evaluation grades may vary as the patient becomes accustomed to existing denture and unable to adequately assess prosthetic functional and biological success relying only on their own experience.

On the other hand, specifics of partial dentures is that such type of construction provides distribution of masticatory pressure transfer to bone through the abutment teeth and the mucous membrane. Zlatarić and Čelebić [30] found that if patient has cortical index equal to 3, clinician can prognose further remodeling and decrease in bone density at the basis of removable prosthetic construction, and such changes progressing much faster than in patients with initial value of cortical index equal to 1. in more recent studies, the same authors found that radiometric parameters of bone density was significantly higher in patients who used partial removable dentures, while in the group of patients who use full removable denture similar levels were much lower, which was apparently triggered by an bone overload through the mucosa. According to scientists, load distribution between the mucous and abutment tooth within construction of partial

denture promotes growth of bone tissue in the cortical part of mandible.

Conclusions. Due to the limitation of provided retrospective literature review based on the systematic results of previous studies we are able to formulate the following conclusions: the use of partial removable dentures in terms of adequate prosthetic treatment pre-planning and maintenance of appropriate hygiene parameters does not cause progressive negative changes of dental status, exceeding the risk of complications specific to progressive partial edentulism without any prosthetic treatment; construction of partial removable dentures can be modified by using different retention elements, each of which is characterized by specific indicators of stress concentration at the place of abutment teeth and the denture base; approaches to improve retention of partial dentures may be clinically promising considering the initial conditions of each specific clinical situation; periodontal status and bone changes under the influence of partial removable dentures justify the use of such type of construction comparing to the designs of full overdentures in clinical cases where it is possible to preserve at least some number of abutment teeth.

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