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Digital Decision-Support System and Orthopedic Dental Rehabilitation in Patients with Periodontitis

Karima Musaeva
Senior Teacher of Hospital Prosthodontics, Tashkent State Medical University, Uzbekistan

N. Meliboyeva
Clinical Resident of Hospital Prosthodontics, Tashkent State Medical University, Uzbekistan

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Abstract

Periodontitis is a chronic inflammatory disease characterized by progressive destruction of the periodontal tissues, loss of clinical attachment, alveolar bone resorption, tooth mobility, and, in advanced cases, partial or complete loss of teeth. Functional impairment resulting from periodontal destruction frequently requires multidisciplinary rehabilitation, including periodontal therapy, occlusal stabilization, and orthopedic dental treatment. The increasing application of digital technologies provides new opportunities for individualized diagnosis, treatment planning, and monitoring of patients with periodontal disease.The proposed clinical protocol includes comprehensive periodontal examination, assessment of tooth mobility and periodontal support, digital intraoral scanning, radiographic or cone-beam computed tomography evaluation when indicated, occlusal analysis, and integration of clinical and digital parameters into a decision-support algorithm. The algorithm stratifies patients according to periodontal severity, residual periodontal support, tooth prognosis, occlusal characteristics, and rehabilitation requirements. Orthopedic treatment planning includes selection of splinting, fixed prosthetic rehabilitation, removable prostheses, implant-supported rehabilitation when clinically appropriate, or combined approaches. Clinical outcomes are assessed using periodontal indices, probing parameters, tooth mobility, occlusal parameters, patient-reported outcomes, and digital monitoring. The proposed digital decision-support model enables systematic integration of periodontal, radiographic, occlusal, and prosthetic parameters. Its implementation may facilitate individualized selection of orthopedic treatment, improve communication between periodontal and orthopedic dental specialists, enhance treatment predictability, and support longitudinal monitoring of rehabilitation outcomes.

Keywords: Periodontitis; digital dentistry; decision-support system; orthopedic dentistry; prosthetic rehabilitation; periodontal support; digital workflow; occlusion; tooth mobility; personalized dentistry.

Introduction

Periodontitis is one of the most common chronic inflammatory diseases affecting the supporting structures of the teeth. The disease is characterized by inflammation associated with dysbiotic dental biofilms and progressive destruction of the periodontal ligament and alveolar bone. In advanced stages, periodontal tissue destruction may lead to increased tooth mobility, pathological migration, loss of occlusal stability, impaired mastication, and tooth loss.

The functional consequences of periodontitis extend beyond the periodontal tissues. Loss of periodontal support changes the biomechanical characteristics of the dentition and may substantially complicate subsequent prosthetic rehabilitation. Teeth with reduced periodontal support demonstrate altered mobility and a decreased capacity to tolerate excessive occlusal forces. Consequently, conventional prosthetic approaches may be associated with unfavorable biomechanical loading if periodontal status is not incorporated into treatment planning.

Orthopedic dental rehabilitation of patients with periodontitis therefore requires a multidisciplinary approach. Periodontal inflammation must be controlled before definitive prosthetic treatment, while the distribution of occlusal forces, residual periodontal support, tooth prognosis, and the presence of missing teeth must be considered simultaneously.

Traditional treatment planning relies predominantly on clinical examination, two-dimensional radiographs, diagnostic casts, and the clinician's experience. Although these approaches remain clinically important, they may provide limited opportunities for quantitative integration of heterogeneous diagnostic information.

The development of digital dentistry has substantially changed the possibilities for diagnosis and treatment planning. Intraoral scanners, digital models, three-dimensional radiographic imaging, digital occlusal analysis, computer-aided design and manufacturing, and virtual articulation can be integrated into a common digital workflow.

Digital technologies are particularly valuable when rehabilitation involves multiple teeth and when the periodontal condition is complex. Digital records can be duplicated, compared over time, and integrated with radiographic and prosthetic data. This creates the possibility of developing a digital decision-support system (DDSS) capable of assisting clinicians in selecting an individualized rehabilitation strategy.

The concept of digital decision support in periodontology and prosthodontics should not be interpreted as replacing clinical expertise. Rather, such a system should provide structured integration of clinical parameters and identify factors that require particular attention before a prosthetic decision is made.

The aim of the study was to develop a digital decision-support system for individualized planning of orthopedic dental rehabilitation in patients with periodontitis and to determine its potential clinical utility in improving diagnostic integration, treatment planning, and postoperative monitoring.

Methods

The proposed investigation was designed as a prospective clinical study evaluating a digital decision-support approach for orthopedic dental rehabilitation in patients with periodontitis.

The study protocol consisted of four principal stages:

Stage I — baseline periodontal assessment

Stage II — digital diagnostic integration and decision support

Stage III — orthopedic rehabilitation

Stage IV — clinical and digital follow-up

The methodology can be adapted to a controlled clinical study, depending on the availability of a conventional-treatment comparison group.

Patients diagnosed with periodontitis who required orthopedic dental rehabilitation were eligible for inclusion.

The final study population should be divided according to periodontal severity and rehabilitation complexity.

A comprehensive periodontal examination was performed in all patients before the initiation of orthopedic dental rehabilitation. The examination was conducted according to a standardized clinical protocol and included assessment of periodontal tissue inflammation, periodontal attachment loss, tooth mobility, furcation involvement, gingival recession, alveolar bone loss, occlusal relationships, and the long-term prognosis of individual teeth.

All teeth present in the oral cavity were examined individually. The findings were recorded using the FDI two-digit tooth numbering system. The clinical parameters obtained during the periodontal examination were subsequently incorporated into the digital decision-support system to provide an individualized assessment of periodontal status and prosthetic suitability. Radiographic examination was performed using appropriate intraoral radiographs and/or panoramic radiography, while cone-beam computed tomography was used when additional three-dimensional information was clinically indicated. The radiographic assessment included evaluation of the height and morphology of the alveolar bone, horizontal and vertical bone loss, angular defects, furcation involvement, and the relationship between the remaining periodontal support and the root length. Radiographic bone loss was recorded in millimeters and/or expressed as a percentage of the estimated root length. The radiographic findings were interpreted together with CAL, tooth mobility, and clinical examination findings.

Occlusal contact assessment. Occlusal relationships were evaluated to determine the functional loading of individual teeth and the distribution of occlusal contacts. The assessment included evaluation of maximal intercuspation, premature contacts, occlusal interferences, pathological tooth migration, and the presence of excessive functional loading. Digital intraoral scans and, where available, digital occlusal analysis were used to complement the clinical examination. Particular attention was given to periodontally compromised teeth that were planned as prosthetic abutments. The presence of excessive or unfavorable occlusal loading was considered when determining whether occlusal adjustment, temporary or permanent splinting, or modification of the prosthetic design was required.

Evaluation of periodontal prognosis. The prognosis of each tooth was determined after integration of clinical, radiographic, functional, and prosthetic parameters. The assessment included the degree of attachment loss, probing pocket depth, bleeding on probing, tooth mobility, furcation involvement, radiographic bone loss, crown-to-root relationship, endodontic and restorative status, occlusal loading, and the strategic importance of the tooth for future rehabilitation.

For the purposes of the digital decision-support system, individual teeth were categorized into three principal prognostic groups. A favorable prognosis was assigned when adequate periodontal support was present, mobility was minimal or physiological, inflammation was controlled, and the tooth could predictably participate in the planned rehabilitation. A questionable prognosis was assigned when periodontal support was reduced or additional risk factors were present, but the tooth remained potentially maintainable following periodontal treatment, stabilization, and appropriate prosthetic planning. An unfavorable prognosis was assigned when severe periodontal destruction, advanced mobility, extensive bone loss, severe furcation involvement, or other factors indicated a poor likelihood of long-term retention and functional use.

The prognostic assessment was not based on a single clinical parameter. Instead, the digital decision-support system integrated the available periodontal, radiographic, occlusal, and prosthetic information to generate an individualized risk profile for each tooth.

Digital Decision-Support System

The central component of the proposed methodology is a digital decision-support algorithm.

The system receives information from four major diagnostic domains:

Each tooth can be classified using a multidimensional assessment.

A conceptual Periodontal-Prosthetic Support Score (PPSS) may be calculated using:

PPSS=w1P+w2B+w3M+w4F+w5O+w6RPPSS = w_1P + w_2B + w_3M + w_4F + w_5O + w_6R

where:

- P = periodontal inflammation parameters;
- B = percentage of alveolar bone support;
- M = tooth mobility;
- F = furcation involvement;
- O = occlusal loading;
- R = restorative/prosthetic value;
- w = weighting coefficient assigned to each parameter.

The exact weighting coefficients should be determined during validation of the system using clinical outcome data.

Orthopedic dental rehabilitation was planned after completion of the initial periodontal examination and stabilization of periodontal inflammation. The selection of the rehabilitation strategy was based not only on the number and location of missing teeth but also on the condition and functional prognosis of the remaining dentition. Particular attention was paid to the amount of residual periodontal support, tooth mobility, clinical attachment loss, radiographic bone loss, furcation involvement, occlusal relationships, and the potential of individual teeth to function as prosthetic abutments.

The principal objective of orthopedic rehabilitation was to restore masticatory efficiency and occlusal stability while minimizing excessive functional loading of periodontally compromised teeth. The treatment plan was individualized for each patient and developed using the data obtained from clinical periodontal examination, radiographic assessment, digital intraoral scanning, and occlusal analysis.

Before definitive prosthetic treatment, all teeth considered for preservation were evaluated according to their periodontal prognosis. Teeth with a favorable prognosis could be considered as individual prosthetic units or abutments. Teeth with a questionable prognosis were considered for inclusion in the rehabilitation only when periodontal stabilization and appropriate biomechanical measures could provide a reasonable long-term prognosis. Teeth with an unfavorable prognosis were excluded from the definitive prosthetic support and were considered for extraction and subsequent replacement when clinically indicated.

The orthopedic treatment options included periodontal splinting, fixed dental prostheses, removable partial dentures, implant-supported prostheses, combined fixed-removable rehabilitation, and temporary-to-definitive prosthetic protocols.

The choice between these treatment modalities was determined individually according to the extent of tooth loss, distribution and quality of the remaining periodontal support, occlusal conditions, prosthetic space, aesthetic and functional requirements, and the patient's ability to maintain adequate oral hygiene and participate in supportive periodontal therapy.

A temporary prosthetic or stabilization stage was used when immediate definitive rehabilitation was considered inappropriate. This approach allowed the periodontal tissues to stabilize and the functional response of the dentition to be evaluated before definitive prosthetic treatment.

The digital decision-support system was used to integrate periodontal, radiographic, occlusal, and prosthetic parameters. Based on these data, the system generated a patient-specific rehabilitation profile and assisted the clinician in selecting the most appropriate treatment strategy.

The general sequence of orthopedic rehabilitation was:

periodontal stabilization → reassessment of tooth prognosis → digital diagnostic modeling → occlusal assessment → selection of prosthetic strategy → provisional rehabilitation where indicated → definitive prosthetic rehabilitation → postoperative monitoring.

Periodontal splinting was considered in patients presenting with clinically significant tooth mobility, functional discomfort, reduced periodontal support, traumatic or excessive occlusal loading, and instability of functional occlusal contacts.

The decision to splint a tooth was not based solely on the presence of mobility. The degree of mobility was assessed together with clinical attachment loss, radiographic bone loss, inflammatory periodontal status, occlusal loading, tooth position, and the overall prognosis of the tooth.

The principal objective of periodontal splinting was to provide functional stabilization of mobile teeth, improve patient comfort during mastication, facilitate distribution of functional forces among several teeth, and create more favorable conditions for periodontal maintenance. Splinting was therefore regarded as a biomechanical component of periodontal rehabilitation rather than simply a method of immobilizing individual teeth.

Before splint fabrication, periodontal inflammation was controlled and the teeth included in the splint were clinically evaluated. The splint boundaries were selected according to the distribution of mobile teeth, periodontal support, occlusal relationships, and the availability of teeth with sufficient periodontal stability to participate in the splint.

Digital intraoral scanning was used, where available, to obtain a three-dimensional representation of the dental arches. The digital model was analyzed to determine tooth alignment, position of the mobile teeth, available interproximal and lingual/palatal surfaces, and occlusal relationships.

The digital planning stage included determination of the optimal splint boundaries, assessment of tooth alignment, virtual design of splint geometry, evaluation of the relationship between the planned splint and occlusal contacts, and preparation of the digital file for fabrication.

The splint was designed to provide adequate stabilization while preserving access for oral hygiene procedures. Excessive extension of the splint into the gingival area or creation of plaque-retentive contours was avoided.

Following placement, occlusal contacts were carefully evaluated to ensure that the splinted teeth were not subjected to excessive static or dynamic loading. The patient was instructed regarding oral hygiene measures, including cleaning of the interdental and subgingival areas adjacent to the splint.

The effectiveness of splinting was subsequently evaluated by reassessing tooth mobility, patient-reported functional discomfort, occlusal stability, periodontal parameters, and integrity of the splint.

Fixed prosthetic rehabilitation was considered in patients in whom sufficient periodontal support remained to provide predictable functional support for the planned prosthesis.

Before selecting an abutment tooth, its periodontal prognosis was evaluated using probing pocket depth, clinical attachment level, bleeding on probing, mobility, furcation involvement, radiographic bone support, crown-to-root relationship, and the presence of endodontic or restorative pathology.

Teeth with favorable periodontal prognosis were preferentially selected as abutments. Teeth with reduced periodontal support were used as abutments only when their condition could be stabilized and the expected biomechanical loading remained within an acceptable range.

An important objective of fixed prosthetic treatment was to provide stable occlusal contacts while avoiding excessive loading of periodontally compromised teeth. The design of the restoration was also required to permit effective oral hygiene and access for future periodontal maintenance.

Particular attention was given to the cervical and proximal contours of the restoration. Overcontoured prosthetic structures and inaccessible restorative margins were avoided because they may interfere with plaque control and complicate periodontal maintenance.

intraoral scanning → creation of a digital diagnostic model → evaluation of tooth position and edentulous spaces → virtual diagnostic wax-up → digital occlusal analysis → prosthetic design → CAD/CAM fabrication → clinical verification → final cementation or fixation.

The digital model was used to assess the proposed restoration before fabrication. The clinician evaluated the relationship between the planned prosthesis and adjacent teeth, antagonist teeth, gingival tissues, and available prosthetic space.

After fabrication, the restoration was clinically evaluated for marginal adaptation, proximal contacts, occlusal contacts, aesthetics, phonetics, and hygiene accessibility.

Following definitive placement, periodontal tissues surrounding the prosthesis were monitored at regular follow-up visits. Particular attention was given to BOP, PPD, plaque accumulation, gingival inflammation, and the condition of the prosthetic margins.

Removable partial prosthetic rehabilitation was considered in patients with extensive tooth loss, insufficient or unfavorably distributed abutment teeth, complex posterior edentulous spaces, or anatomical and clinical limitations that prevented predictable fixed or implant-supported rehabilitation.

The selection of abutment teeth for removable prostheses was performed according to the same periodontal principles as for fixed prosthetic rehabilitation. Teeth with advanced mobility or severe periodontal destruction were not used as primary supporting elements unless their prognosis could be improved and the biomechanical design adequately compensated for their reduced periodontal support.

The principal objective of removable prosthetic design was to distribute functional loads over the available supporting structures while minimizing excessive forces on periodontally compromised teeth.

Particular attention was paid to the location and number of rests, guiding surfaces, direct and indirect retainers, and the relationship between the framework and the periodontal tissues.

Digital planning was used, where available, to facilitate three-dimensional surveying, determination of the optimal path of insertion, positioning of clasp assemblies, framework design, evaluation of support and retention, and assessment of the relationship between the planned prosthesis and the remaining dentition.

intraoral scanning → digital cast generation → survey and analysis → determination of insertion path → identification of potential abutments → framework design → virtual verification → CAD/CAM fabrication → clinical adjustment.

The prosthesis was adjusted clinically to ensure adequate retention and stability without excessive pressure on the periodontal tissues.

Patients received detailed oral hygiene instructions concerning both the remaining teeth and the removable prosthesis. The importance of removing and cleaning the prosthesis according to the prescribed protocol was emphasized.

During follow-up, the periodontal condition of the abutment teeth, plaque accumulation, BOP, tooth mobility, prosthesis stability, mucosal condition, and patient comfort were evaluated.

Implant-supported rehabilitation was considered in appropriately selected patients after periodontal disease had been adequately controlled and the patient's oral hygiene and maintenance status had been evaluated.

The decision to proceed with implant-supported rehabilitation was based on a comprehensive assessment of periodontal stability, residual bone volume and morphology, implant-site anatomy, prosthetic space, occlusal conditions, oral hygiene, patient-related risk factors, and the feasibility of long-term supportive periodontal care.

Particular attention was paid to the history and severity of periodontitis because patients with previous periodontitis require careful periodontal monitoring before and after implant placement.

Radiographic examination, including three-dimensional imaging when clinically indicated, was used to evaluate available bone volume, anatomical structures, bone defects, and the relationship between the planned implant position and adjacent anatomical structures.

Digital implant planning was performed by integrating the three-dimensional radiographic dataset with the digital intraoral model. This allowed the proposed implant position to be evaluated in relation to the future prosthetic restoration.

intraoral scanning + CBCT → data integration → virtual implant positioning → prosthetic-driven planning → surgical guide design where indicated → implant placement → digital prosthetic planning → definitive restoration.

The prosthetic position of the implant was planned before surgical intervention whenever possible. The implant was therefore considered as part of a prosthetically driven rehabilitation strategy rather than as an isolated replacement for a missing tooth.

After implant-supported rehabilitation, patients were included in a structured periodontal and peri-implant maintenance program. Follow-up examinations included assessment of oral hygiene, peri-implant soft tissues, probing findings where appropriate, radiographic bone levels when clinically indicated, prosthetic integrity, occlusal relationships, and patient-reported functional outcomes.

Occlusal assessment constituted an important component of the diagnostic and rehabilitation protocol because periodontal destruction may alter the biomechanical behavior of the dentition. Reduced periodontal support, tooth mobility, pathological migration, and changes in the distribution of occlusal forces may influence the selection and design of orthopedic treatment.

Occlusal assessment was performed before definitive prosthetic rehabilitation and repeated after treatment to determine whether the planned rehabilitation produced stable and physiologically distributed occlusal contacts.

The assessment included evaluation of maximal intercuspation, distribution and intensity of occlusal contacts, premature contacts, occlusal interferences, anterior guidance, lateral guidance, and the distribution of functional forces.

Where available, digital occlusal analysis was integrated with the three-dimensional intraoral model. This allowed the clinician to visualize the relationship between tooth morphology, prosthetic design, and occlusal contacts.

The digital analysis was particularly important when planning rehabilitation involving periodontally compromised teeth. Teeth with reduced periodontal support were assessed for excessive functional loading, and the prosthetic design was modified when necessary to reduce unfavorable loading.

The digital occlusal protocol included the following sequence:

digital intraoral scan → registration of maxillary and mandibular arches → virtual articulation → assessment of static occlusal contacts → evaluation of dynamic contacts → identification of premature contacts/interferences → prosthetic modification → post-treatment verification.

The preoperative and postoperative digital records were compared to determine changes in the distribution of occlusal contacts following rehabilitation.

The principal objective was not to achieve complete elimination of occlusal contacts but to establish a stable and functionally appropriate occlusal relationship that would avoid excessive loading of periodontally compromised teeth and provide adequate support for the prosthetic rehabilitation.

Discussion

The rehabilitation of patients with periodontitis represents a significant clinical challenge because prosthetic treatment is performed in a biologically compromised environment.

Traditional prosthetic planning frequently begins with the identification of missing teeth and selection of prosthetic replacement. However, in patients with periodontitis, this approach may be insufficient because the remaining teeth differ substantially in their periodontal support and biomechanical prognosis.

A digital decision-support system offers an alternative approach in which the prognosis of individual teeth and the functional requirements of the entire dentition are assessed simultaneously.

One of the major advantages of digital integration is the ability to combine information from different diagnostic sources. Periodontal probing provides information about soft-tissue and attachment conditions, radiographic imaging demonstrates hard-tissue support, while digital models provide information about tooth position and occlusal relationships.

Integration of these datasets allows the treatment plan to move from a predominantly subjective assessment toward a structured decision-making process.

An additional advantage is the ability to preserve baseline digital records. This is particularly important in chronic periodontal disease because treatment success depends not only on the initial response but also on long-term maintenance.

Serial digital scans can potentially demonstrate tooth migration, changes in gingival contours, restoration wear, and other alterations that may not be readily appreciated during routine visual examination.

However, digital decision-support should not replace clinical judgment. Algorithms are dependent on the quality of input data and require appropriate clinical validation. In particular, prognosis cannot be determined solely from numerical parameters because patient-specific factors, treatment compliance, biological response, and maintenance behavior substantially influence outcomes.

The proposed model should therefore be considered a clinical decision-support tool rather than an autonomous diagnostic system.

Conclusion

The integration of digital dentistry and decision-support methodology represents a promising approach to the orthopedic rehabilitation of patients with periodontitis.

A digital decision-support system allows periodontal, radiographic, occlusal, and prosthetic information to be integrated into a unified treatment-planning process. Such integration may improve identification of suitable abutment teeth, facilitate selection of appropriate prosthetic rehabilitation, reduce the risk of excessive functional loading, and provide an objective framework for long-term monitoring.

The most important principle is that orthopedic rehabilitation should be considered as part of a periodontally oriented multidisciplinary treatment strategy, rather than as an isolated prosthetic procedure.

Further prospective clinical studies are required to validate the proposed scoring system, determine its diagnostic and prognostic accuracy, and establish whether digital decision support produces measurable improvements in periodontal stability, prosthetic survival, functional outcomes, and patient-reported quality of life.

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