Overview

Immediate loading of single implants in the posterior region: a narrative review of clinical considerration

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Abstract

This narrative review evaluates the clinical considerations of immediate loading protocols for single dental implants in the posterior region. Immediate loading offers advantages such as reduced treatment time and improved patient comfort but requires strict criteria to ensure success. Primary implant stability—commonly assessed by insertion torque and resonance frequency analysis—has been proposed as a critical prerequisite for immediate loading; however, optimal threshold values remain controversial and appear to be influenced by multiple clinical and biomechanical factors. Bone characteristics varies in significantly affects outcomes, with the posterior mandible typically providing better support due to higher density and thicker cortical bone layer. Guided surgical techniques enhance placement accuracy and reduce complications compared to freehand methods. Despite generally high success rates, both mechanical and biological complications still remain concerns. Overall, with careful case selection and appropriate technique, immediate loading is a reliable and predictable option for single posterior implants.

Keyword: *Immediate Loading; Single Implant; Posterior Region; Primary Stability.*

1. INTRODUCTION

Oral diseases are increasingly becoming a public concern as their prevalence continues to rise and can affect individuals throughout their lifetime. According to the Global Burden of Disease Study 2015, approximately 3 to 5 billion people worldwide suffer from oral health issues, primarily untreated dental caries, severe periodontal disease, which eventually leads to severe tooth loss (having only 1 to 9 teeth remaining in the dental arch) [1]. In terms of the pattern and prevalence, most lost teeth were in the posterior region and mandibular first molar was by far the most frequently extracted tooth due to dental caries followed by maxillary first molar [2, 3]. Consequently, loss of posterior teeth, especially mandibular first molars, affects the masticatory function, temporomandibular system, aesthetics, structural balance, as well as psychological aspects of patients [4, 5].

There are various methods for partially or fully restoring masticatory function and aesthetics for missing teeth, such as removable dentures, resin-bonded bridges, fixed bridges, and dental implants. Among these, dental implant placement has demonstrated outstanding advantages, overcoming the limitations of traditional prosthetic methods, while providing aesthetics and function that closely resemble natural teeth. It is also safe and reliable, with a success rate of up to 97% over 10 years and 75% over 20 years [6].

Historically, the recommended implant installation protocol has been a two-stage surgery, with the sinking of the implants followed by a healing period free of mechanical load of 3 months for the mandible and 6 months for the maxilla [7]. However, the major disadvantage of this protocol with late loading is the use of temporary prostheses without, in most situations, stability, and retention, generating situations of discomfort; frequent adjustment needs; new surgery to expose the implants, in the case of a two-stage surgical protocol; possible psychological and social problems [8].

Recently, as the demand increases for procedures that are less invasive, quicker, and better meet aesthetic expectations, implant placement with immediate loading is gradually becoming more common in clinical practice [9]. Thanks to the obvious advantages of single-stage implant installation and the constant development of the implants and surgical techniques, immediate loading of single implants has been utilized in various regions of the mouth, with high rates of success and survival [10]. According to a study by Mugri M.H. et al., immediate loading of implants in the posterior region showed a high success rate of 94.31% [11]. In the study by Gjelvold B. et al., the survival rate of immediately loaded implants (100%) was higher

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compared to the delayed loading group (90.5%) [12]. Immediate loading implant treatment depends on multiple factors: patient selection, bone quality and volume, primary stability, the surgeon's skill, occlusal adjustment, and the patient's diet [11]. Among these factors, primary stability is the most crucial condition for achieving biological stability during the initial healing period [13].

This narrative review aims to critically analyze the key clinical factors influencing the success of immediately loaded single implants in the posterior region, with particular emphasis on primary stability thresholds, bone density, implant location, and biomechanical loading conditions.

2. IMPLANT LOADING TIME PROTOCOLS

2.1. Definition

A Cochrane systematic review by Esposito et al. categorized the timing of implant loading into three types, and defined them as follows:

1. Immediate loading was defined as an implant put in function within 1 week after its placement.

2. Early loading as those implants put in function between 1 week and 2 months.

3. Conventional (also termed delayed) loading as those implants loaded after 2 months.

The overall outcomes of this Cochrane systematic review was no convincing evidence of a clinically important difference in either implant failure, prosthesis failure, or bone loss associated with different loading times of implants [14].

Over the past few decades, implant placement and loading protocols have been analyzed separately from one another even though the implant placement technique and its related surgical outcome at the time of placement are determinant factors for selecting the loading protocol [15]. Consequently, International Team for Implantology (ITI) Consensus Statements published in 2018 combined implant placement and loading protocols into 12 well-differentiated protocol types and used this new comprehensive combination as a single denominator for implant survival and success [15, 16].

In this systematic review, the placement protocols were classified into four types, which are late implant placement; early placement with soft tissue healing; early placement with partial bone healing, immediate placement [15].

Meanwhile, regarding to loading protocols, the definition has been slightly modified over the years through the last ITI Consensus Conferences in 2014 and were defined as follows [15, 17]:

1. Conventional loading: Dental implants are allowed a healing period more than 2 months after implant placement with no connection to the prosthesis.

2. Early loading: Dental implants are connected to the prosthesis between 1 week and 2 months after implant placement.

3. Immediate loading: Dental implants are connected to the prosthesis within 1 week subsequent to implant placement.

The differences between the Cochrane and ITI definitions reflect the evolution of implantology from a time-based approach toward a biologically and prosthetically driven concept. In this review, the ITI classification is primarily adopted, as it integrates implant placement timing with loading protocols and better reflects contemporary clinical decision-making.

2.2. Subgroup classification

Immediate loading protocol is divided into subclassifications to point out the different loading modality. In relation to occlusal contact of restoration, Degidi and Piattelli described differences between functional and nonfunctional loading. Immediate functional loading of implants involved patients receiving prostheses with occlusal function on the day of implant placement [18]. Meanwhile, nonfunctional immediate loading (termed immediate restoration by this consensus group) involved the provision of a prosthesis 1 to 2 mm short of occlusal contact or not in direct occlusion in static or dynamic lateral movements with the antagonistic dentition [14, 18].

Moreover, immediate loading protocol is also classified into direct loading and progressive loading. Esposito et al. defined progressive loading as the load of the implants obtained by the gradual increase of the occlusal table height through increments from infra-occlusion to complete occlusion [14].

3. IMPLANT PRIMARY STABILITY

3.1. The role of primary implant stability

Osseointegration occurs in two levels: primary (associated with the mechanical engagement of an implant with the surrounding bone after implant insertion) and secondary (related to bone regeneration and remodelling to the implant) [19, 20]. Primary stability, defined as the biometric stability immediately after implant insertion, is a critical factor that determines the long-term success of dental implants [21]. Although micromovements have been considered as one of the main reasons for osseointegration failure, the tolerated micromotion threshold between 50 and 150 microns could even stimulate the newly formed bone to remodel, accelerating the osseointegration process around an early loaded implant [22, 23, 7].

Among all the factors affecting the success and survival rates of immediate loading implant treatment, primary stability is the most crucial condition for achieving biological stability during the initial healing period [11, 13]. This determinant is influenced by many factors including local bone quality and quantity, implant macro-design and surgical technique [24-28].

Successful immediate loading at low insertion torque values may be explained by several contributing factors, including strict non-functional loading protocols, favorable implant macro-designs that enhance bone-implant contact, controlled occlusal schemes, and placement in bone types with adequate cortical support (D2/D3). These findings suggest that insertion torque alone should not be considered an absolute determinant, but rather part of a multifactorial stability assessment.

3.2. Implant primary stability evaluation

There are various techniques utilized to identify the stabilization of immediate loaded implants such as insertion torque value measurement, the periotest and resonance frequency analysis.

Insertion torque value (ITV) measurement in dental implantology is a key indicator of implant primary stability, which also plays an important role in deciding the loading protocol and eventually affects the implant survival [29,30]. A higher ITV generally suggests better primary stability and a more favorable prognosis for osseointegration. Although ITV may vary from study to study, the value ranged from 30 to 45 Ncm is considered as the immediate loading threshold to ensure implant stability during osseointegration and to provide adequate strength for implant-abutment connection [17, 31-33]. In contrast, a retrospective clinical study by Norton showed a high survival rate up to 95.5% when evaluating immediate loaded single implants installed with low torques (≤ 25 N cm) [34]. Therefore, the optimal torque or ISQ value required for successful osseointegration is still unclear, and more clinical studies on this subject are needed [9].

Two other methods to measure the primary stability are the resonance frequency analysis and the Periotest.

Resonance frequency analysis (RFA) combined with insertion torque is another important evaluation metric for immediate/early loading [31]. In 1998, Meredith et al. introduced RFA as a non-invasive and objective quantitative clinical technique to establish valuable information for monitoring implant success and osseointegration [35]. RFA is measured as an Implant Stability Quotient (ISQ) on a scale of 1 - 100, with relatively stable implants having relatively high ISQ values (> 60) [35]. A study by Margossian et al. indicated the 2-year success rate up to 93.3% in the immediate provisionalization with occlusal loading group and 100% in no occlusal loading group with ISQ ≥ 60 [33]. Similarly, researches by Degidi et al. and Fung et al. suggested ISQ ≥ 60 with low ITV as an evaluation criteria for immediate load [36,37].

The Periotest (PT) indicates implant stability by measuring the time of contact between the instrument's tip and the implant, during repetitive percussions generated by this device [38]. Signals produced by tapping are converted to unique values called ‘‘periotest values - PTV’’ ranging on a scale of −8 to +50, with the negative range presenting better stability [38, 39]. According to Dilek et al., immediate loading could only occur when PTV was in the range of -8 to +9 [40]. Results by Lorenzoni et al. reported that 100% successful loaded implants had PTV between -2 and -4 [41].

In clinical practice, insertion torque, ISQ, and Periotest values should be interpreted collectively. In cases of discordance-for example, high ITV but low ISQ-clinicians should prioritize the overall biomechanical environment and consider modifying the loading protocol toward non-functional or progressive loading rather than immediate functional loading.

4. IMPLANT POSITION AND BONE DENSITY

The implant success and survival rates in posterior maxilla and mandible are different due to the variations of bone characteristics.

In 1988, Misch proposed four (D1 - D4) bone type groups based on macroscopic cortical and trabecular bone characteristics (density) located in edentulous areas of the maxilla and mandible [42]. In this classification, D1 and D2 bone types (dense cortical and cancellous bone) are mostly found in the posterior mandible whereas D3 and D4 bone types (less dense, more porous trabecular bone) are frequent in the posterior maxilla. Turkyilmaz et al. evaluated bone density using computed tomography and reported a mean density of 674.3 ± 227 Hounsfield units (HU) for the posterior mandible, which was higher than the mean density of 455.1 ± 122 HU for the posterior maxilla [43]. Thanks to the higher bone density with thicker cortical bone layer, immediate loaded implants in mandibular posterior regions gain better primary stability and success rates compared to those in [44-47].

In addition, various research has shown that immediate loading in the mandible upregulates cellular activity, including increased expression of alkaline phosphatase (ALP) and osteocalcin (OCN), which are markers of bone formation [48]. This suggests that the mandible may have a higher capacity for bone remodeling under immediate loading conditions. Moreover, immediate loading in the mandible has been associated with faster healing and higher bone formation ratios compared to the maxilla [48, 49]. The maxilla's healing patterns are often slower, which may necessitate delayed or early loading protocols to ensure proper osseointegration [44, 50].

On the contrary, a systematic review by Mugri et al. reported that immediately loaded implants in the maxillary posterior region had a better success rate (95.025%) compared to the mandibular region (91.93%) [11]. The possible reason may be the incidence of high masticatory forces in the posterior mandible which could affect the survival rate of the implant [9].

Although the posterior mandible generally provides superior primary stability due to higher bone density, this advantage may be counterbalanced over time by greater occlusal and masticatory forces, potentially challenging secondary stability. In contrast, the posterior maxilla, despite lower initial bone density, may experience reduced functional loading, which could partially explain the higher reported success rates in some studies. Whether these differences are statistically and clinically significant remains uncertain and warrants further investigation.

5. SURGICAL TECHNIQUES

Gentle surgical placement is also a key element for implant success regardless of the applied treatment protocol [51]. Currently, thanks to the advent of cone beam computed tomography in surveying the anatomical structure in three-dimension and rapid development of technology in surgical guides design and fabrication, guided implant surgery has become more common. In terms of immediate loaded single implant in posterior regions, guided implant surgery has various superior advantages compared to free-hand protocol, including enhanced precision; improved safety by reducing the risk of injuring adjacent anatomy; prosthetic predictability through a full digital workflow and prosthetic predictability [52-55].

A systematic review about immediate single implants in posterior found a pooled 1-year success rate approximately 94.3% [11]. However, many included studies report no significant difference in survival between immediate and conventional loading techniques as well as guided and freehand approaches. In addition, a meta-analysis found that implant failure freehand surgery was 3-fold higher than guided protocol [52].

Despite its advantages, guided implant surgery has limitations in the context of immediate loading, including higher costs, increased laboratory time, limited intraoperative flexibility for achieving optimal primary stability, and potential inaccuracies in patients with restricted mouth opening.

6. COMPLICATIONS

The immediate loading protocol may lead to technical as well as biological complications.

Immediately loaded single restoration in the posterior regions commonly exhibit technical issues, which are most frequently fractures of the prostheses, loosening of the abutment screws and denture contouring adjustments [56]. For example, a prospective study in 2024 reported the prevalence of major prosthetic complications including proximal contact loss (41.67%), loosening of the screw (8.33%), and cement debonding (4.17%) [57]. Additionally, an article related to immediate functional loading of single implants also showed a high incidence of prosthetic complications, such as loosening of the prosthetic abutment (5.7%) and a fracture of the ceramic veneer in a metal–ceramic crown (1.9%) [58].

Biological complications involve peri-implantitis, peri-implant mucositis, marginal bone loss. Particularly, the prevalence of peri-implant health, peri-implant mucositis, and peri-implantitis disease following immediate implant placement and loading amounted to 38.3%, 57.5%, and 4.2% of the patients, respectively [59]. Another systematic review with meta-analysis calculated 7.1% soft tissue complications after 5 years, with 5.2% of the implants showing bone loss above 2 mm [60].

7. CONCLUSIONS

In conclusion, immediate loading of single implants in the posterior region represents a promising advancement in implant dentistry, characterized by reduced treatment time and improved patient comfort. Achieving adequate primary stability, indicated by insertion torque values of ≥30–45 Ncm and ISQ values of ≥60, is crucial for success. Factors such as bone density, implant location, and surgical technique significantly influence outcomes, with guided implant surgery providing enhanced accuracy and lower failure rates. While immediate loading offers favorable survival and success rates, it is not without risks, including mechanical and biological complications. Therefore, careful patient selection, meticulous surgical execution, and ongoing postoperative care are essential for long-term success in this treatment modality.

Given the relatively high prevalence of peri-implant mucositis and peri-implantitis, immediate loading in posterior regions should be accompanied by strict postoperative protocols, including meticulous oral hygiene instruction, occlusal monitoring, soft diet recommendations during early healing, and close follow-up intervals to mitigate biological complications.

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