

# Biological Response of Self-Ligation Bracket Systems

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**Received date:** June 14, 2024, **Accepted date:** June 22, 2024, **Published date:** July 01, 2024.

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Frictional forces in continuous arch mechanics must be overcome for a favourable periodontal response for tooth movement. It accounts for 60% of the applied force that necessitates extra force, causes anchorage loss, and prolongs treatment time. Optimum force levels stimulate cellular activity without completely occluding blood vessels in the periodontal ligament. Higher forces are likely to create a hyalinized avascular area that must be revascularized before the next phase. A proper understanding of the magnitude of the frictional force enables the clinician to apply adequate force for optimal tooth movement and favourable tissue changes.

Proffit proposed that the optimum force levels for orthodontic tooth movement would be just high enough to stimulate cellular activity without completely occluding blood vessels in the PDL. If a force is great enough to occlude the blood vessels and cut off the blood supply, a hyalinized, avascular area is formed that must

revascularize before teeth can move. Pain is related to the development of ischemic areas in the PDL. Tencate suggested that oxygen is the trigger mechanism in the periodontium. According to Proffit, if vascularity is critical to tooth movement, there is no doubt that light, continuous forces produce the most efficient tooth movement and that heavy forces should be avoided. Rygh recommended light, continuous forces for more effective tooth movement in areas with cortical bone or bone with few marrow spaces.

Proffit noted that "root remodeling is a constant feature of orthodontic tooth movement, but that permanent loss of root structure occurs only if repair does not replace the initially resorbed cementum. Activating an appliance too frequently, short-circuiting the repair process, can produce damage to the teeth or bone that a longer appointment cycle would have prevented or at least minimized. If the appliance is springy and light forces

produce continuous frontal resorption, there is no need for further activation."

Warita compared the application of a light, continuous force (5g/f) versus a light, dissipating force (10g/f) for 39 days on rat molars. He found 1.8 times greater tooth movement with the light, continuous force. Histological observation showed that the PDL applied with light continuous force tended to be more physiologically preserved than that applied with light dissipating force. Clearly, the use of light, continuous forces and appropriate appointment timing can dramatically enhance patient comfort and shorten treatment.

Orthodontic therapy is not contraindicated for patients with advanced periodontal destruction, provided that factors such as inflammation, plaque, subgingival calculus, and occlusal trauma are well controlled both before and during the orthodontic treatment. The application of extremely light continuous forces might have a better effect on the cell biology of tooth movements. By minimizing necrosis, and the subsequent hyalinization and indirect resorption, it might be possible to achieve continuous progress in tooth movement, avoiding the repeated interruptions occurring when the blood vessels are occluded, and reducing the great risk for further bone loss when treatment is rendered for individuals with decreased osseous support.

Periodontal diseases include a group of chronic inflammatory disorders encompassing destructive and non-destructive diseases of the periodontal supporting tissues of the teeth. Chronic periodontitis is a common disease and may occur in most age groups, but is most prevalent among adults and seniors worldwide. Pressure from the lips, cheeks, and tongue in the rest position, and the forces produced by the metabolic activity of the periodontal membrane, are the two major factors affecting the balance that dictates the position of the teeth. When the periodontium is intact the periodontal membrane counteracts possible soft tissue imbalances. However, when the periodontium is compromised, the

teeth might be more susceptible to migration. It has been shown that orthodontic forces in the presence of plaque can create intraosseous defects, and that following rotation and intrusion of teeth, loss of attachment can be observed. The combination of orthodontic forces, inflammation, and traumatic forces can cause more rapid destruction than that produced by inflammation alone. It is also known that in the presence of periodontitis, traumatic forces develop that combined with inflammation can act synergistically, accelerating the development of the periodontal disease.

Orthodontic tooth movement in adults can be slower than tooth movement in adolescents due to differences in the biomechanical properties of the adult periodontium. Reduced cellular activity in adults facilitates the formation of hyaline zones and the conversion of collagen fibers is much slower than in children and teenagers. Heavy orthodontic forces overcoming the blood pressure of the capillaries cause crushing of the periodontal ligament on the pressure side, resulting in hyalinization and slowing of the tooth movement. Gentle forces can cause light ischemia with concurrent bone resorption and formation and enhance tooth movement. The rearrangement of the dental arch may facilitate oral hygiene and positively influence the outcome of the periodontal treatment, while the observable esthetic improvement may motivate the individual even further regarding the pursuit of their oral rehabilitation.

Pre orthodontic periodontal therapy is directed toward the etiologic factors including plaque, subgingival calculus, and occlusal trauma. Occlusal therapy is an integral part of periodontal therapy. Failure to treat occlusal trauma appropriately in patients with chronic periodontitis may result in progressive loss of bone and an adverse change in prognosis, and could result in tooth loss. Root planing and subgingival debridement are performed to help diminish inflammation, bleeding, and suppuration. Following a stabilization period, the patient is reevaluated and the tissue response is assessed. The periodontist determines if the patient is stable enough periodontally to

proceed with orthodontic treatment. Systematic scaling and cleaning might be necessary on a 3 monthly basis, and occasionally even shorter recall periods could be indicated. In case of adult orthodontics self-ligating brackets are far more useful because they generate low friction and low force thereby the effect on the periodontium will be lesser when compared to other brackets. The time taken for the periodontium to heal will be more in case of adults and therefore these brackets will generate lesser pressure causing lesser damage to the periodontium.

On investigating the amount of external apical root resorption (EARR) between conventional and passive self-ligating brackets no difference was found in the amount of EARR between appliance systems. Age, sex, and extraction treatment were not reliable predictors of EARR, but a positive association between EARR and duration of treatment was observed. No difference should be expected for root resorption between conventional and passive self-ligating brackets. Blunting or shortening of the root apex, a condition often associated with orthodontic treatment.

The teeth more susceptible to EARR are the maxillary and mandibular incisors, and especially the maxillary lateral incisors. A number of studies have evaluated the role of variables such as age, sex, trauma, malocclusion, dental root anatomy and agenesis, mechanotherapy and appliance type, characteristics of tooth movement, type of orthodontic force, and treatment time in the development of EARR. Patients with EARR in the early stages of treatment are more likely to experience severe resorption after orthodontic therapy.

The contributing role of continuous tooth movement across various paths, an undesirable effect known as "tooth jiggling," and the application of intermaxillary elastics in the development of EARR have been highlighted. Treatment duration independent of appliance type was a significant predictor of EARR, with an average increase of 0.03 mm per month.

Root resorption can be underestimated because of the inherent deficiency of panoramic x-rays to show EARR in a facial direction. Several recent studies explored this factor by evaluating the 3-dimensional morphology of roots after force application by using advanced instrumentation. These results, albeit with the foregoing limitation, support previous findings reporting mild EARR that is slightly more evident on the lateral incisors. Additionally, sex and patient age at the start of treatment among adolescents were not found to affect EARR, whereas treatment duration had a positive association with the amount of EARR.

Comparing conventional and self-ligating brackets by Blake et al, who found no difference in the amount of root resorption. Interestingly, the use of light and constant forces has been linked with higher EARR prevalence. Specifically, Weiland demonstrated that the mode of persistent activation of nickel-titanium wires, deriving from their considerably increased work range relative to their stainless steel counterparts, might be related to increase EARR<sup>72</sup>. maxillary incisors induced by orthodontic treatment using self-ligating brackets (Damon Q, DQ) or conventional brackets (Titanium Orthos, TO) with the help of cone-beam computed tomography (CBCT). He concluded that Higher incidence of slanted RR was found in patients treated with the TO system and suggested that it warrants further research to identify possible specific causes.

Enamel decalcification is a common problem in orthodontics. Plaque bacteria surrounding 2 bracket types, self-ligating (SL) vs elastomeric ligating (E) were compared, and whether adenosine triphosphate (ATP) driven bioluminescence could be used for rapid assessment of bacterial load. In SL attachments the plaque had fewer bacteria in plaque than did teeth bonded with E brackets. The presence of acid-producing bacteria, colonizing the tooth surface and surrounding orthodontic appliances, leads to enamel demineralization and often causes alterations in the appearance of the enamel surface. These changes are an esthetic problem that can

persist for many years after treatment. In addition, decalcification related to bonded orthodontic appliances appears to occur primarily near the appliance and not farther away along the facial surface. Thus, the prevention of demineralization at the periphery of the brackets is a significant challenge to orthodontic professionals. Bonded brackets have many advantages over bands because of better esthetics, ease of placement and removal, and accessibility for oral hygiene. Nonetheless, bonded orthodontic brackets impede good oral hygiene, resulting in plaque accumulation and significantly increased risks for enamel decalcification.

After the bonding of orthodontic appliances, there are documented increases in the amounts of cariogenic microorganisms, *Streptococcus mutans* and *Lactobacilli*, in saliva and dental plaque of patients. Rapid adenosine triphosphate (ATP)-driven bioluminescence assays have long been used as a quantitative measure of microbial numbers and more recently in dental plaque. Bioluminescence assays measuring energy metabolites, including ATP, have been shown to have high correlations with plaque mass obtained from both human and animal subjects. Iatrogenic decalcification of tooth enamel and the development of visible white spot lesions are undesirable and unfortunate consequences of fixed orthodontic therapy, potentially undermining the esthetic benefits often achieved through correction of the malocclusion.

Fixed appliances increase bacterial plaque accumulation and the risk for white spot lesions facilitated the efficiency of orthodontic appliance construction, but also reduced the amount of tooth surface covered with appliances. Nonetheless, bonded orthodontic brackets hinder access for good oral hygiene and create microbial shelters, resulting in the accumulation of plaque. The appliance architecture specifically, the archwire ligation method is an additional factor influencing bacterial colonization. In most patients, the teeth bonded with the SL appliance had fewer bacteria than those bonded with the E appliance.

Gorelick et al and Mizrahi found maxillary incisors and first molars to have the highest prevalence of white spot lesions. Gorelick et al found that the maxillary lateral incisors had the highest incidence for white spot lesions, with the second most commonly affected teeth the maxillary central incisors. Interestingly, they found that length of treatment had little effect, with patients in treatment for 12 to 16 months experiencing the same incidence of white spot lesions as those with longer treatment schedules for up to 36 months.

Fluoride releasing compounds and fluoridated elastomers have been introduced, with questionable success for sustained enamel protection. Home care regimens, such as daily sodium fluoride mouth rinses, have demonstrated significant measures of protection but suffer from potential noncompliance this requires additional cooperation from patients for maximum effectiveness. In a scanning electron microscopic histologic study, Sukontapatipark et al found the area around the bracket base almost completely covered with a thick accumulation of bacteria in 1 week after placement of the appliances and attributed this to excess composite, with adjacent smooth areas exhibiting a less mature monolayer of bacteria.

Decalcification related to bonded orthodontic appliances occurred immediately around the appliance and not farther away along the buccal surface. Based on observations that the maxillary lateral incisors have the highest prevalence of white spot lesions, ostensibly on the facial tooth surfaces at the immediate during treatment, there is demonstrated increased retention in the amounts of *Streptococcus mutans* and *Lactobacilli* in saliva and dental plaque. Forsberg et al studied the effect of microbial plaque retention around fixed appliances ligated with steel ligatures and elastomeric ties in 12 patients.

Using circum bracket sampling techniques, they found that the maxillary lateral incisors that were attached to archwires with elastomeric rings had more bacteria than

incisors ligated with steel wires. They recommended avoiding the use of elastomeric ligatures in patients with poor oral hygiene because elastomeric ligation rings can significantly increase microbial accumulation on tooth surfaces adjacent to the brackets, leading to predisposition for dental caries and gingivitis.

Based on the results of Forsberg et al, which indicated reduced bacterial retention around brackets ligated with steel ligatures as opposed to elastomeric ties, it was a logical hypothesis that the complete absence of a ligature a self-ligating mechanism would presumably be equally as hygienic, if not better than a stainless steel ligature. The placement of steel ligatures on all brackets is time consuming and rarely done routinely in most orthodontic practices.

Further studies should be done to compare the difference between steel ligatures and SL brackets. The subjects we studied included some who maintained exquisite oral hygiene, with minimal plaque retained around the appliances, regardless of appliance type. Although this is desirable and encouraged for all our patients, it might not represent the oral hygiene of patients outside well-controlled clinical trials.

A survey of patients who had completed fixed orthodontic treatment found that 91% experienced pain during treatment. The origin of orthodontic-related pain is thought to be in the periodontal ligament by the processes of pressure, ischemia, inflammation, and edema. Many inflammatory mediators shown to elicit hyperalgesia responses, such as histamine, prostaglandins, serotonin, bradykinin, and substance P, have increased levels in the periodontium during orthodontic tooth movement. Postoperative dental pain (PDP) is frequent after various forms of dental treatment.

The incidence and severity of PDP in adults have been shown to be correlated with specific forms of dental treatment: the highest after endodontic treatment (52.8%) and the lowest after restorations (36.1%). In addition,

women (52.5%) reported PDP more often than men (33.7%).

According to Damon his fixed appliance system is superior to other systems because of the combination of a low- friction bracket and a low force generated by superelastic nickel-titanium archwires that result in more efficient tooth movement and less pain.

The Damon 3 patients reporting lower mean maximum pain intensity than the Tru Straight patients; the lower mean maximum pain intensity with the Damon bracket might be due to the method of ligation and subsequent force applied to the teeth. Closure of the slide on the Damon 3 bracket passively engages the wire in the bracket slot; this might apply less active force than elastic modules (used with Tru Straight); thus, there is the potential for freedom of movement for a 0.014-in wire in the Damon 3 slot. This might be translated to the interbracket area, since the archwire can pass through adjacent brackets without being forced against the slot base, unlike the module that engages each bracket tightly. Furthermore, modules engage the tie-wings around the circumference of the bracket; this further reduces the interbracket span, compared with the Damon 3 slide.

Psychological factors might be important in determining a patient's subjective reaction to orthodontic force, and this is possibly more important than the force magnitude. Anxiety lowers the pain threshold and can cause the perception of normally nonpainful stimuli as painful; patients reporting pain might be attempting to translate their feelings into a tangible physiologic problem. Patients in the Damon 3 group reported lower mean maximum pain intensity (difference, 11.77 mm; 95% CI, -0.15-23.68 mm) than did the Tru Straight group. Damon 3 patients reported, on average, statistically significant lower mean pain intensity than did the Tru Straight patients ( $P = 0.012$ ), and the difference between the bracket types was consistent at all time points. Patients who consumed analgesia reported statistically significantly higher mean maximum pain intensity and

mean pain intensity than those who took none ( $P < 0.001$ ). Patients reported statistically significant higher pain intensity on day 1 before dinner compared with day 2 before dinner and for all subsequent pain recordings [75]

Pseudoelastic and thermoelastic wires are generally considered to have the properties to deliver forces of low magnitude. However, their unloading forces can be as high as 879 g/mm for a 0.016\*0.022 wire. To obtain forces lower than 100 g per tooth from austenitic superelastic nickel titanium, indicated for periodontally compromised patients, it is necessary to select wires of smaller diameters and abandon the use of rectangular wires during the alignment phase of treatment. Even the 100 g of force per tooth on a severely compromised periodontium can be considered as “heavy” and should be reduced.

Thus, the smallest available diameter wires might be more appropriate in patients who have reduced bone and gingival support. Another controversial factor that might have been overlooked in clinical practice is the frequency of appliance activation. Traditionally, orthodontists follow a 4- week activation cycle corresponding to the bone resorptive portion of the human remodeling cycle that lasts about 1 month. Animal experiments have shown that when appliances were reactivated following total deactivation, tooth movement could be more efficient. Wires with extensive and constant unloading curves (eg, superelastic thermally activated wires), which under circumstances of reduced friction like those previously described, may remain active for prolonged periods of time, and could allow for less frequent activations since their total deactivation might take a longer period of time. Clinical experience has shown that activation intervals of 8 to 10 weeks might be more appropriate for enhancing tooth movement.

Occasionally, especially in cases where severe crowding is present or when transverse dentoalveolar expansion is desirable, these intervals may even be prolonged further. The low friction characterizing passive selfligating

brackets, the freedom of the small pseudoelastic wires to move within the brackets, and the exertion of very light forces with minimal permanent deformation of the wire for extended periods of time all fulfill the definition of “convergent technologies,” which is the ultimate goal in what is considered as “front line” industry. These might be the proper arsenal for treating patients with a reduced but controlled and healthy periodontium.

The following is a report of a patient who had severe periodontal damage and who was treated by applying the principles described in this article. When compared with patients with similarly compromised periodontal tissues treated with more conventional techniques, differences in outcomes could be detected. This approach to periodontally compromised patients appears to be more appropriate based on the present day understanding of force levels and tissue responses.

Heber Arbildo 2018 compared the clinical periodontal effect of CB and SLB through a systematic review and metaanalysis and concluded that no differences were detected in the periodontal clinical effect of patients who received orthodontic treatment with conventional and self-ligating brackets.

Reconstruction of a maxillary dentoalveolar defect and closure of a wide oronasal fistula in a patient with a traumatic injury are challenging for both orthodontists and surgeons. A conventional bone graft is used to fill the alveolar bone defect, to restore continuity between bony segments, and to provide bony support for tooth eruption adjacent to the defect or for orthodontic tooth movement into the bony defect. However, if the defect is too large to allow for a conventional bone graft, transport distraction osteogenesis can be used for reconstruction of the alveolar bone and implant placement.

However, there is usually a discrepancy in the movement rates between the bony segment and the teeth. Passive self-ligating brackets can minimize friction between the bracket and the archwire; therefore, the rate of tooth

movement can be balanced with that of the bony segment. By using orthodontic miniscrew and elastomeric traction, the regenerated bony segments can be bent to form a curved arch in the alveolar bone. Trifocal distraction-compression osteosynthesis with orthodontic miniscrews and passive self-ligating brackets helped establish bone continuity in a bony defect area, created anterior curvature of the alveolar bone, and provided good quality regenerated bone for implant placement.

Lina Golz et al determined salivary Ni<sup>2+</sup> concentrations in patients undergoing orthodontic treatment with self-ligating fixed appliances. Self-ligating orthodontic appliances affect salivary Ni<sup>2+</sup> concentrations in vivo over the short term. However, in this levels resembled those documented in conjunction with conventional bracket use and remained below the daily dietary Ni intake.

Ana Zilda nazar bergamo et al evaluated the break homeostasis in the oral environment and the levels of microorganisms associated with dental caries among the different types of brackets. Twenty patients received two self-ligating brackets: InOvation®R, SmartClip™, and one conventional Gemini™. Saliva was collected before bonding (S0), 30 (S1) and 60 (S2) days after bonding. The orthodontic appliances break the salivary homeostasis of microorganisms involved in dental caries. The contamination pattern was different between self-ligating and conventional brackets. The InOvation®R presented worse performance considering the levels of cariogenic bacterial species.

Treatment principles are mainly based on science but art is also a part of it. Through the years, the evolution and advent of several bracket systems have been introduced into the field of orthodontics, has guided and at the same time misguided the clinician in his planned mechanotherapy.

While it is advocated that low-friction SL brackets coupled with light forces enhance the treatment efficiency and address the clinical superiority of self-

ligating brackets, other team believes that bracket type does not appear to have a significant influence on treatment efficiency. Treatment efficiency is the product of many mechanical and biologic factors. It is unlikely that any one factor is responsible for the efficiency and rate of tooth movement. The biology of tooth movement is a complex and highly coordinated process at the cellular, molecular, and genetic levels. Individual variation undoubtedly has a fundamental underlying role in tooth movement and treatment efficiency. SL bracket systems are only a tool that we use today; therefore, they are just a component of orthodontics.

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