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Iatrogenic Effects of Orthodontic Treatment- A Review

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ABSTRACT

Introduction: Orthodontic treatment aids in the improvement of function, esthetics, and the patients' self-confidence. Iatrogenic damage during orthodontic treatment is believed to have deleterious effects on the dentition & periodontium. The complications associated with orthodontic treatment are a result of a multifactorial process including the patient's biology, clinical skills of the orthodontist, orthodontic appliances, orthodontic treatment procedures, and length of treatment.

Aim: The purpose of this study is to summarize the scientific-based evidence on the iatrogenic effects that may be associated with orthodontic treatment and thereby discuss methods of prevention by reviewing various articles published under this topic.

Methodology: The database collected from PubMed, PubMed Central (PMC), Cochrane library, Google scholar and research gate were studied and thus all available information has been reviewed and briefed in this article.

Discussion and Conclusion: If the orthodontic treatment is to be beneficial, the advantages it offers should outweigh any possible damage it may cause. It is important to assess the risks of treatment as well as the potential gain and balance these aspects of treatment before deciding how to treat the malocclusion. Further studies and controlled trials on the aetiology and intensity of each effect concerning every influencing factor are required.

Key Words: Orthodontics, Iatrogenic, Resorption, Hypersensitivity, Allergy, Demineralisation

INTRODUCTION

Orthodontic treatment is being practiced since the 1800s and the benefits gained are voluminous like improvement in dental health, function, appearance, and self-esteem. Although orthodontic treatment has many such recognized benefits, orthodontic appliances can cause unwanted complications if adequate care is not taken during the treatment.¹

Iatrogenic is derived from the Greek word "iatros" meaning physician and "gen" meaning 'producing'. Identifying the risk factors, causes, and ways to prevention is important for a successful orthodontic treatment and the oral health of the patient. Adequate knowledge on these complications has to be imparted to the patient and necessary counselling on his role in avoiding these have to be given. There is less literature on the consolidated review of all the observed iatrogenic effects and ways to prevent them during orthodontic treatment. This review article aims to discuss various iatrogenic effects of orthodontic treatment and ways to avoid the occurrence of these for a successful orthodontic treatment.²

WHITE SPOT LESION

The white spot lesion (WSL) has been defined by Fejerskov *et al.* as the first sign of caries-like lesion on enamel that can be detected with the naked eye.¹ Enamel decalcification in the form of white spot lesions is a consequence of improper oral hygiene while undergoing orthodontic treatment (Fig 1). They appear as small lines along the bracket periphery or as large decalcifications with or without cavitations.²



Figure 1: Facial surface of maxillary anterior teeth. (Photo courtesy: Chapman et al, Risk factors for incidence and severity of white spot lesions during treatment with fixed orthodontic appliances. AJODO 2010)

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A sudden increase in the number of WSLs occurred during the first 6 months of treatment and continued to increase at a slower rate to 12 months, thus maintaining proper oral hygiene is critical in the initial months of the treatment.³ According to Oggard *et al.*, 1988 the occurrence of WSLs in orthodontically treated patients was maximum in lateral incisors followed by canines, first premolars, 2nd premolars, and central incisors. The incidence rate is 45.8% and the prevalence rate is 50%–96% in patients undergoing orthodontic treatment, which is quite alarming.^{4,5}

Diagnosis: There are various methods to identify which include visual inspection, photographs, fluorescent methods, and optical modalities such as diagnosed, quantitative light-induced fluorescence, and digital image fibre-optic transillumination. Benson *et al.*, 2003 considers quantitative laser techniques as more sensitive, yielding a higher prevalence rate than the simple visual technique.^{6,7}

Prevention and management

a) Maintain Oral Hygiene: Mechanical plaque control by proper tooth brushing, interdental brush, disclosing solutions, floss, water irrigation or powered toothbrush can be used⁸.

b) Fluoride Toothpaste: Fluoride toothpaste contains sodium fluoride, monofluorophosphate or stannous fluoride (1500-5000 ppm) where fluoride ions get incorporated into the surface of enamel forming fluorapatite crystals. Soneson *et al.*, proves that they reduced the incidence of WSL by 32%.^{9,10}

c) Fluoride Mouth rinse: Fluoridated mouth rinses containing 0.05% sodium fluoride used daily or every other day reduced WSL by 25%. Antibacterial agents like chlorhexidine, triclosan, or zinc have been incorporated into these mouthwashes to improve their cariostatic effects.^{10,11,12}

d) Fluoride Varnish: Varnishes adhere to the enamel surface longer than other topical fluoride products and do not require patient compliance. 5% NaF forms a reservoir of calcium fluoride on the tooth surface and prevents demineralization by 30- 50% when applied biannually.^{13,14,15}

e) Fluoride Releasing Banding Cement

Resin Modified Glass Ionomer Cement (RMGIC) pumps fluoride by absorbing from the environment and releasing it in the most susceptible areas.¹⁶ Bishara *et al.* reported a very less initial bond strength of RMGIC with a failure rate of 24.8%.^{17,18}

Bioactive glass (BAG) is a cross-linked matrix of hydrolyzed alkoxides of SiO₂ and CaO that releases ions such as calcium, fluoride into the oral environment and prevents demineralization of enamel. Manfred *et al.* showed that BAG-Bond adhesives have better microhardness than Transbond-Xt.¹⁹

f) Elastomeric ligatures: Tin fluoride (SnF) containing elastomeric ligature ties release a low concentration of fluoride for a long period. Wiltshire *et al.*, 1996 reported an initial burst of fluoride-release (35%) during the first 24 hours followed by a continued release of 63%, 83%, and 88% of the total fluoride in the first week, first month, and second month, respectively.^{20,21}

g) Pit and fissure sealants: The application of resin sealants on the enamel surface surrounding the bracket protects the enamel surface from acid attack. Benham *et al.* reported a decrease in WSL by 3.8 times with sealants.^{22,23} Sealant combined with brushing was more effective in protecting enamel than brushing alone.²⁴

h) Xylitol: Xylitol is a polyol (a type of carbohydrate) that is not metabolized by S mutants and can be used as a sugar substitute. It is available as chewing gum or lozenges.²⁵ Xylitol lozenges reduce the acidogenicity of dental plaque by increasing the pH value.²⁶

i) Laser irradiation: Laser irradiation is a new method for inhibiting demineralization around orthodontic appliances which is regularly combined by fluoride therapy. Meurman *et al.* showed that it is possible to convert hydroxyapatite crystals to fluorapatite crystals instantly in the presence of fluoride using a CO₂ laser.²⁷

j) Intraoral fluoride-releasing devices: Copolymer Membrane Device, Glass Device Continuing Fluoride, Slow-Fluoride Release Tablets. These devices can significantly increase the salivary fluoride concentration without substantially affecting the urinary fluoride levels.²⁸

ROOT RESORPTION

External apical root resorption (EARR) is defined as a physiologic or pathological process characterized by the loss of cementum or dentine resulting in the shortening of the root apex²⁹. When heavy orthodontic forces are applied for a long duration (weeks or months), necrosis (hyalinization) of the compressed PDL may occur. The defensive leukocytes that migrate out of PDL capillaries include osteoclast progenitors that promptly coalesce to form multinucleated cells, capable of resorbing mineralized tissues (bone and tooth roots).³⁰

Stages of root resorption, as proposed by Levander and Malmgren, which was further modified by Beck and Harris in 1994 (Fig 2).³¹

Figure 2: Root resorption index acc. to Malmgren et al., 1982. Root resorption after orthodontic treatment of traumatized teeth. AJO. 1982
(Grade 0: Normal root length)

- Grade 1: Irregular root contour
 Grade 2: Root loss apically, <2mm
 Grade 3: Root loss apically, 2mm to 1/3rd root length
 Grade 4: Root loss exceeding 1/3rd of root length)

Krishnan *et al.*, reported a genetic influence in those individuals homozygous for IL-1 β (+3953) allele 1 where the risk of root resorption increased by 5.6-fold.³⁰

Maxillary teeth are more sensitive than mandibular teeth as their extent of movement is greater and their root structure and periodontium tend to transfer the forces mainly to the apex. The use of fixed appliances is more detrimental to the roots than removable appliances.³² The use of elastics that give jiggling forces, rapid maxillary expansion with cervical traction, has been reported to cause severe root resorption of the first maxillary molars.^{33,34} Intrusion is the most damaging to the roots involved.³⁵ Agap in treatment with intermittent forces permits the resorbed cementum to restore and avoids further resorption.³⁶

In the view of accelerated orthodontics, which mainly acts by RAP (Regional Acceleratory Phenomenon), the inflammatory markers (cytokines) activate the cementoblasts and it increases the chance of root resorption.³⁷

Diagnosis: Several radiographic techniques used include periapical radiograph, orthopantomogram, cephalogram, and laminogram as it provides the most appropriate information with the least irradiation to the patient.³²

Prevention and management: Clinical considerations^{30,32}

- Frequent periapical radiographs, at least every year during active treatment
- The orthodontic force should be for a short duration, intermittent and minimal.
- Traumatized teeth should be treated with utmost care since they are more prone to root resorption.
- Eliminate pressure habits
- Occlusal traumatism and jiggling are detrimental to the roots
- If any root resorption is found, an inactive phase of 4 to 6 months before resuming orthodontic treatment is advised. In extreme cases, an interdisciplinary approach is adopted³⁵.

DENTIN HYPERSENSITIVITY

Injudicious use of interproximal reduction (IPR) can result in hypersensitivity. IPR is done to manage tooth mass discrepancy, late secondary crowding problems, prevent relapse by stabilizing dental contacts over the long-term, and eliminate black triangles in periodontal patients and reshaping the canines in congenitally missing lateral incisors. Around 0.2mm- 0.6mm can be removed from the mesiodistal surfaces of the teeth based on the tooth. The air-rotor with fine

tungsten-carbide or diamond burs/ disks and abrasive metal strips are used³⁸.

Hypersensitivity depends on various factors such as the age of the patient, severity of crowding, pathological tooth wear, hypersensitivity before treatment, and the amount of the enamel removed.³⁹ The sensitivity is mild, transient and the symptoms usually subside over time⁴⁰.

Prevention and management

Identifying the thickness of enamel by projecting a line from the cervical line vertically to the occlusal plane because dentin is projected in a straight line from the cervical line or using special gauges, aligning the rotated teeth before striping, finishing and polishing with superfine strips, using a fluoride mouth rinse or denitrifies, or professional interventions through the application of fluoride varnish to promote remineralization can be done.⁴¹⁻⁴³

PERIODONTAL PROBLEMS

Orthodontic appliances interfere with oral hygiene procedures and contribute to plaque accumulation.⁴⁴ Vanarsdall *et al.* observed that the gingival changes associated with orthodontic appliances are transient and they resolve themselves or will respond to professional oral prophylaxis measures. Gingival recession is the exposure of root surfaces due to apical migration of the gingival tissue margins.⁴⁵ Marginal tissue recession or attachment loss is associated with thermal and tactile sensitivity, esthetic complaints, and root caries.⁴⁶

Morris *et al.* reported that orthodontic treatment is not a major risk factor for the development of gingival recession. However, larger amounts of maxillary expansion may increase the risk of recession after treatment.⁴⁷

Prevention and management

When pre-existing gingival recessions are found before orthodontic treatment, the impact of orthodontic treatment should be carefully evaluated. If the tooth is planned to move lingually, tooth movement alone can end up treating or at least not aggravating the recession. If the tooth is to be moved labially, a mucogingival procedure to avoid disease progression must be planned. OTM may be initiated once wound healing is complete (3-4 months). When a gingival recession occurs during tooth movement, soft tissue grafting is indicated and is performed as soon as possible. Orthodontic therapy should be carefully evaluated to determine whether to stop or slow down OTM until wound healing is complete⁴⁸.

BLACK TRIANGLE

Open gingival embrasures, also known as black triangles, refer to space below the interproximal contact when space is

not filled with gingiva. They cause esthetic and periodontal problems related to chronic food retention.² Adult orthodontic patients show a relatively high incidence of 38 to 43.7% of open gingival embrasures despite their high esthetic demands (Fig 3).⁴⁹



Figure 3: Black triangle.

(Photo courtesy: Pugliese F *et al.*, Black triangles: Preventing their occurrence, managing them when prevention is not practical. Semin.Orthod. 2019)

Ageing, thin periodontal biotype, increased distance from the contact point to the alveolar bone, divergent or triangular shaped crown forms, incisively placed interproximal contact, root angulation a (1° increase in root divergence increased the odds of an open gingival embrasure by 14- 21%) pose a major risk factor for the black triangle.⁵⁰ Burke reported that a black triangle is a consequence of aligning crowded maxillary central incisors. One-third of orthodontic patients are likely to have crowded central incisors, of which two-fifths of them are likely to have a post-orthodontic black triangle.⁵¹

Prevention and management

Periodontal management by papilla preservation or papillae regeneration with soft tissue graft can be advised. Restorative approaches to change the shape of the crown. Orthodontic treatment to converging roots of central incisors (normal gingival embrasures converges at 3.65°) and restorative approaches by reshaping the triangular crown shape results with reduction of interproximal enamel (IPR) using diamond strips or discs (0.5- 0.75 mm of enamel is removed with IPR).⁵²

SOFT TISSUE INJURY

Intraoral appliances

Patients may have mouth ulcers, due to pricking of wires, bands, brackets or, cleats on the lips and cheeks. Oral tissues rapidly adjust to the new appliance and in the meantime, vegetable wax can be used to give temporary relief. Sometimes, palatal/ lingual bars may cause trauma to the palate or tongue. Some patients damage their appliances frequently, they are

counselled about diet and habits and extra precautions such as placing bands rather than bonds are taken.⁵³

Extraoral appliances:

In 1975 the American Association of Orthodontists reported in an editorial that they come across several rare situations in which patients undertaking extraoral traction appliances had sustained facial injuries.⁵⁴

The extraoral injuries involve the cheeks, chin and, eye. Injury from headgear is the most common and is commonly due to:

- Accidental disengagement when the child was playing while wearing the headgear
- Incorrect handling by the child during the fitting or removal of the headgear
- Deliberate disengagement of the headgear caused by another child
- Unintentional disengagement or detachment of the headgear during sleep

The current safety devices available to counter injuries are safety release or snap-away head caps/neckstraps, plastic safety neck straps, and several designs of safety face-bows. They should be given both verbal and written safety instructions after fitting headgear.^{54,55}

Micro implant injuries

Micromplants are commonly used in absolute anchorage cases. Ellis and Benson discussed the most frequent complications and accidents are the contact between adjacent tooth roots, mucositis, contamination, and mini-implant fracture during placement or removal. Inflammation of soft tissues (poor oral hygiene and implants on free gingiva) around the mini-implant is a possible complication for TADs, which may lead to loss of stability (Fig 4).⁵³

Gingival soft tissue thickness must be considered when choosing the most appropriate type of mini-implant and incomplete engagement into the cortical bone during placement leads to miniscrewslippage.^{56,57}

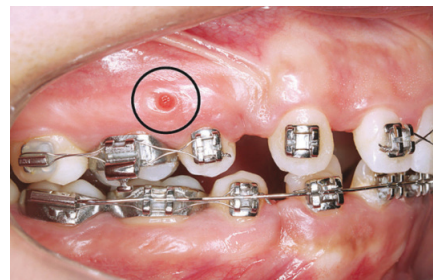


Figure 4: Mini implant injury.

Photo courtesy: Consolaro *et al.*, Reasons for mini-implants failure: choosing installation site should be valued!. Dental Press J Orthod. 2014

Due to accelerated orthodontics

Of all the available techniques for accelerated orthodontics, corticotomy is known to double the rate of tooth movement⁵⁸. Even though Wilko brothers claim it to be a routine periodontal procedure, surgery-assisted techniques are invasive with bone loss, postoperative pain, swelling, infection, avascular necrosis, and moderate morbidity.^{59, 60}

Ingestion of appliance components

Accidental ingestion or inhalation of foreign bodies in orthodontics range from brackets, bands, buccal tubes, lingual arches and quad-helix, removable appliance fragments, sectional archwire fragments, coil springs, expansion appliance keys, and retainers.⁶¹

When a foreign object is lost at the back of the mouth, it is expected to pass through the gastrointestinal tract, rather than the respiratory tract. The British Orthodontic Society advises that any object ingested that is smooth, flexible and, less than 5 cm in length passes through the GIT uneventfully, whilst larger objects are more prone to obstruct or perforate the GIT.⁶²

Prevention⁶¹⁻⁶⁴

- Identifying at-risk patients during history taking
- Ensuring high-speed suction and appropriate barrier techniques such as rubber dam, gauze, or cotton wool rolls.
- Small orthodontic components can be protected from ingestion by attaching floss or wax.
- Appliances, both fixed and removable, should be retentive.
- Every removable appliance should have a radio-opaque component and should be without any sharp edges.
- An upright position can be used instead of a supine position for some patients and procedures.
- Unsupported archwires should be supported with sleeves or tubing.

Any missing appliance or component is checked for at each visit. Acting immediately to retrieve the foreign body clinically, and using radiological data in deciding to retrieve or observe.

Due to aligners

With the advances in 3D printing and manufacturing, aligners is an emerging technology to treat malocclusions⁶⁵. Even though they showed a reduced incidence of root resorption, the treatment outcome showed no difference.^{66, 67} On analysing the MAUDE (Manufacturer and User Facility Device Experience) database, serious adverse clinical events- e.g., difficulty in breathing, swollen throat, anaphylactic reaction, swollen lips, laryngospasm, blisters could be associated with the use of Invisible aligner systems.⁶⁸

ALLERGY

An allergic response is one in which the immune system of our body reacts extremely to a foreign substance. Two key allergic reactions have been described in the literature. A delayed hypersensitivity reaction (Type IV) is an allergic immune reaction manifesting primarily through T cells (Cellular immunity).⁶⁹

Allergy in patients undergoing orthodontic treatment can be due to several reasons and these include nickel allergy, allergy to the acrylic resins that are used during treatment, latex products, etc.

Nickel

Nickel alloys are widely used in an orthodontic practice in the form of brackets, wires, bands, and other components. Signs and symptoms of nickel allergy include gingivitis, gingival hyperplasia, lip desquamation, burning sensation in the mouth, metallic taste, angular cheilitis, and periodontitis (Fig 5).^{69, 70}



Figure 5: Nickel allergy.

(Photo courtesy: Staerkjaeret al., Nickel allergy and orthodontic treatment. EJO 1990)

Kim *et al.* suggested in such patients stainless steel, titanium molybdenum alloy, fibre-reinforced composite wires, gold plated wires, ion-implanted nickel-titanium archwires, or plastic/resin-coated nickel-titanium archwires can be used⁷¹. Ceramic brackets or even plastic aligners are a good alternative. Extra-oral metal components like headgear studs can be replaced with plastic coated studs⁷².

Latex

Natural rubber latex is found in gloves, intra and extra-oral elastics, separators, elastomeric modules, elastomeric power chains, polishing rubber cups. Severe systemic reactions, involving the skin, airways, and/ or cardiovascular systems, have been reported after cutaneous and respiratory exposure⁷³.

A definitive diagnosis should be based on the previous medical history and a positive skin reaction to the particular chemicals present in natural rubber latex. In the latex-sensitive patient,

stainless steel ligatures, self-ligating brackets and, self-locking separating springs may be preferred. Synthetic non-latex gloves made from nitrile, polychloroprene are available as an alternative.

Acrylic resin

Acrylic resins based on methyl methacrylate can produce type IV hypersensitivity reactions.⁷³ Generally, allergic reactions to acrylic are local manifestations- labial oedema, erythema delineating the contact area, burning sensations, and chronic urticarial.

Other substitutes to methyl methacrylate include covering the acrylic portion with ultraviolet polymerized urethane acrylate or using polycarbonate. Clear plastic retainer or lingual bonded retainers can be used.⁷⁴

CONCLUSION

The in above-stated manuscript, the details of various iatrogenic effects possibly caused due to orthodontic treatment have been discussed, thereby enumerating the ways to prevent them or manage them as per the patients' requirements. Patient's oral hygiene, type of orthodontic treatment, and treatment duration are some of the most common causes. Recognition of the iatrogenic effects is critical to the orthodontist and the patient. It is essential to obtain a thorough medical, dental, and family history before starting the treatment. Progressive diagnostic records during the treatment such as radiographs and photographs stage by stage might be helpful and monitoring of the periodontal status is of great importance for the success of therapy. Clear communication with the patient regarding the risks and benefits of the planned orthodontic treatment is important to avoid any future misinterpretations. Clinicians must obtain a signed consent for treatment and the associated risks involved.

The aetiology of iatrogenic effects of orthodontic treatment is multifactorial, hence this review article may not suffice or do justice to the entire problem. Future studies are required which individually concentrate on each iatrogenic effect and conduct a study based on the occurrences in vivo.

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