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Review Article

Iatrogenic Effects of Orthodontic Treatment

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***ABSTRACT*:**
Iatrogenics may be described as a situation that leads to reversible or irreversible damage to patients that undergo any type of treatment. The dynamics of facial development and growth, the biomechanical interactions between appliances, dentition and bones, patient-family interaction, variety of treatment approaches and the continuity of follow-up during the retention phase are the variables that must be considered properly during orthodontic treatment. Iatrogenics might also involve some problems caused by the patient. This is recognized in the orthodontic publications mainly in terms of failures in patient compliance that result in poor treatment, no improvement, or damage.
Keywords: Allergy; Gingivitis; Orthognatic Surgery; Resorption; White Spot Lesions.

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INTRODUCTION

Orthodontic treatment has many recognized benefits, including improvement in dental health, function, appearance, and self-esteem. Nevertheless orthodontic appliances can cause unwanted complications if adequate care is not taken during the treatment.[18] Like any medical therapy, orthodontic treatment exposes the patient to certain risks. From an ethical standpoint, the clinician must understand how these risks relate to each patient to ensure that they will receive a net benefit from treatment[36].

Iatrogenics usually occurs due to: Inaccurate growth prediction, incorrect choice of orthodontic appliances, technical failure by the dentist, poor patient cooperation, lack of control of space and anchorage, particularly when teeth are extracted for orthodontic reasons[6].

1. DENTAL EFFECTS

A. CROWN

a. DECALCIFICATION/WHITE SPOT LESIONS

The most frequent iatrogenic problem in orthodontics is white spot lesion occurring in crown region (Figure 1). WSL are clinically defined as opaque, white areas caused by loss of minerals below the outermost layer. It is the earliest sign of carious process, which starts with enamel demineralization[15].

Figure 1: White Spot Lesions

DETECTION: Macroscopic methods: Clinical examination, photographs, optical nonfluorescent methods & optical fluorescent method. Microscopic methods: Caries & In Situ caries model.

TREATMENT: Conservative methods: Oral hygiene instructions, dietary modification, chewing gum to increase salivary output (having xylitol), remineralization with fluoride (in dentrifices, varnishes, sealants, mouth rinses with low concentration solutions of less than 50 ppm), use of antimicrobials (chlorhexidine) & casein derivatives. Aggressive methods: External bleaching, micro abrasion, composite restoration & porcelain veneers[7]

b. DECAY

The most common side effect of orthodontic treatment is that they cause changes in mouth flora due to the formation of non-cleanable surfaces, and therefore they cause areas of decalcification on the enamel and eventually periodontal diseases (Figure 2).

RELATIONSHIP BETWEEN ORTHODONTIC APPLIANCES AND DENTAL CARIES: The irregular surfaces of fixed or removable orthodontic appliance act as a retention area for bacterial biofilm & presence of the orthodontic appliances limits the mechanical self-cleaning process provided by saliva and musculature movement[30].

MANAGEMENT OF THE PATIENT WITH DECALCIFICATION DURING ORTHODONTIC TREATMENT: Microabrasion, Resin infiltration, Self-assembling peptides.

Figure 2: Decay

CARIES FORMATION: The proposed hypothesis suggested by Chang et al. is as follows (fig 3):[34]

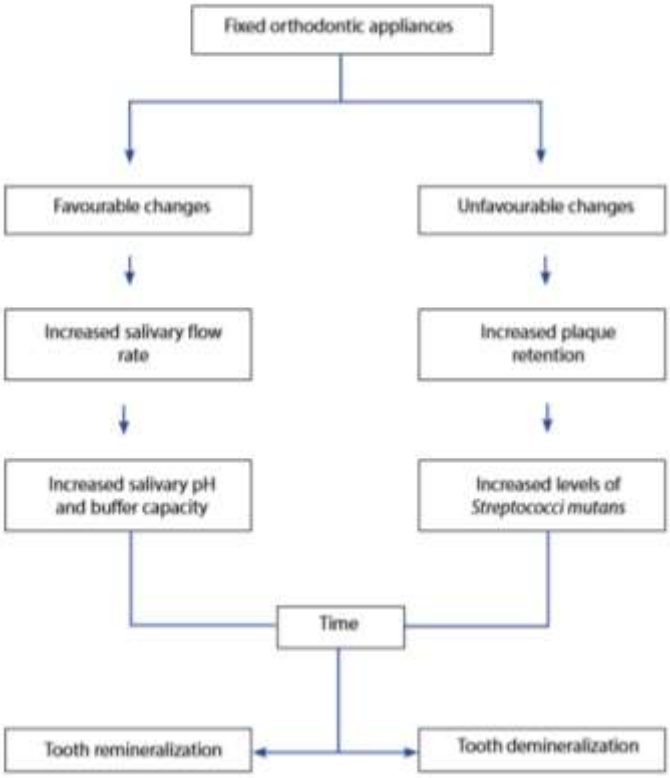

Figure 3: Decay progress

c. ENAMEL CRACKS AND FRACTURES

Enamel microcrack (EMC) – a microcrack located in the enamel that usually does not cross the dentin-enamel junction (DEJ) and has no loss or visible separation of tooth structure (FIGURE 4 & 5). This type of EF causes stain and plaque accumulation on the rough fractured surface[11].

Figure 4: Enamel Crack & Fractures

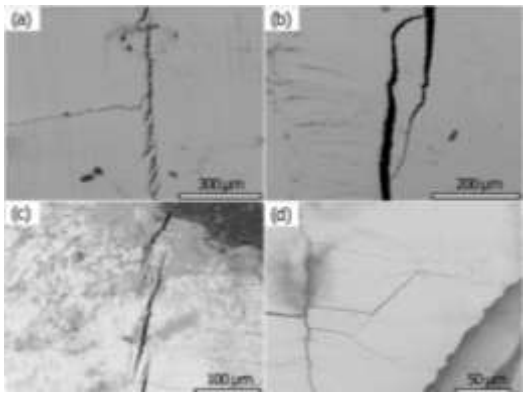

Figure 5: A closer look to EMCs from scanning electron microscope (SEM) micrographs at various magnifications

DETRIMENTAL EFFECTS ON TEETH: May jeopardize the integrity of the enamel, cause stain and plaque accumulation on the rough fractured surface, Increase susceptibility to carious lesions, compromise the appearance of the teeth & effect on teeth sensitivity[8].

B. ROOT RESORPTION

Excessive force during orthodontic treatment increases the risk of root resorption, particularly if heavy continuous forces are used. Prolonged duration of orthodontic treatment also increases the amount of resorption (fig 6 & 7).

Figure 6: Pre treatment

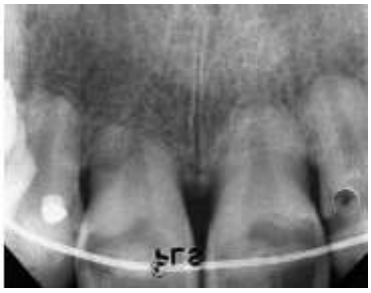

Figure 7: Post treatment

Apical root resorption (loss of root length) during orthodontic treatment occurs in three distinct forms that must be distinguished when its etiology is considered.

1. Moderate Generalized Resorption
2. Severe Generalized Resorption
3. Severe Localized Resorption[23]

CLINICAL RECOMMENDATIONS TO PROTECT PATIENTS FROM DEVELOPING EXTERNAL APICAL ROOT RESORPTION (EARR): EARR can be minimized in orthodontic patients by moving teeth with light forces, through trabecular bone, with periodic radiographic monitoring and, most importantly, by moving them the least distance possible. This may be accomplished by using the following root-sparing orthodontic treatment regimes: Growth modification to correct severe skeletal Class II malocclusions, Early interception of maxillary canines that have mesial eruption paths, Serial extraction to modify eruption paths (guidance of eruption), Correction of anterior open bite with a palatal tongue spur appliance & Orthognathic surgery to avoid moving teeth large distances and against cortical plates.

MANAGEMENT: Imaging (Initial periapical radiograph or limited field CBCT), Progressive review (monthly clinical review), Are there any methods to detect EARR before it is visible on radiographs (Gingiva, crevicular fluid (GCF) is an intriguing possibility[13] & Genes).

C. PULP

Any alteration in pulpal blood flow or vascular tissue pressure can endanger the health of the dental pulp. Study by Oppenheim showed some severe signs of pulpal degeneration. This concluded that, because of the lack of collateral circulation, the pulp is one of the most sensitive tissues in the human body[14]. Orthodontic force has been hypothesized to alter pulpal blood flow (PBF) and thereby considered to cause pulpal tissue changes[27].

2. PERIODONTAL EFFECTS

A. GINGIVITIS

When a fixed orthodontic appliance is placed, most patients develop generalized gingivitis, irrespective of whether banded or bonded attachments are used[28].

Study by Balenseifen and Madonia also confirmed an increase in the Lactobacillus population with orthodontic appliances. Study by Alstad & Zachrisson revealed that after removal of the fixed appliances orthodontic patients had significant lower plaque scores and less gingivitis (fewer bleeding points) than the untreated persons[2].

MANAGEMENT: Electrical toothbrush, Chlorhexidine, Duration of treatment, Urea peroxide, Menthol & thymol oil & Diode laser.

B. GINGIVAL RECESSION

A 'gingival recession' (Figure 8a & b) is defined as the displacement of the marginal tissue apical to the cementoenamel junction.

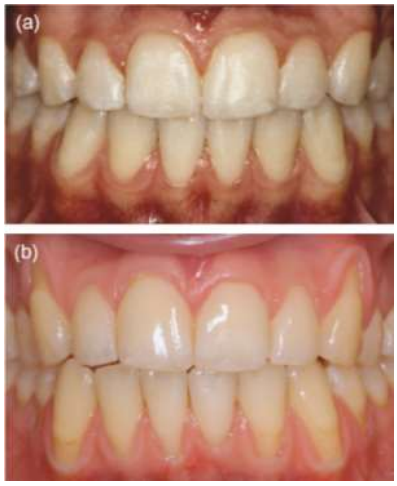

Figure 8: Development of labial gingival recessions after orthodontic treatment:(a) immediately post-treatment and (b) 5 years later

AETIOLOGY: Co-occurrence of dehiscences in the alveolar bone and gingivitis is critical for the development of gingival recession in many clinical situations. Furthermore, buccal gingival recessions have been associated with a thin symphysis, excessive proclination of mandibular incisors with displacement of the cervical region of the roots outside the alveolar cortical bone.

TREATMENT: Dentinal hypersensitivity may occur in some patients because of gingival recession. For most patients, the sensitivity can be resolved with over-the-counter toothpastes. If a patient is concerned about continuing gingival recession and poor esthetics is evident, then a surgical corrective procedure may be warranted[21].

C. ALVEOLAR BONE LOSS

A basic axiom in orthodontics is ''bone traces tooth movement,'' which suggests that whenever orthodontic tooth movement occurs, the bone around the alveolar socket will remodel to the same extent. However, sometimes there may not be coherence with this rule, and an unfavorable bone response may occur after incisor retraction. Labial bone protuberance usually causes esthetic problems, and alveloplasty can be used to eliminate excess alveolar bone.[37]

Assessing loss of interdental alveolar bone radiographically is superior to clinical methods. Since the introduction cone-beam computed tomography (CBCT) in dentistry has become an useful tool in the assessment of the condition of periodontal tissues. Rapid palatal expansion provokes horizontal and vertical reductions in the buccal alveolar bone of premolars and molars according to three-dimensional (3D) studies[20].

D. DEHISCENCE & FENESTRATION

The lack of facial or lingual cortical plates, which results in exposing the cervical root surface and affecting the marginal bone, represents an alveolar defect called dehiscence (Fig 9). When there is still some bone in the cervical region, the defect is termed fenestration (Fig 10).

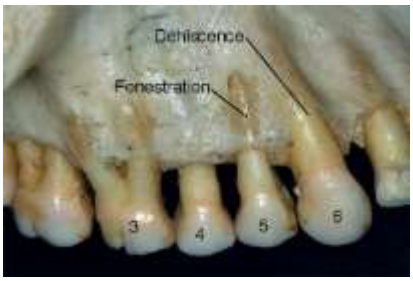

Figure 9: Dehiscence

Figure 10: Fenestration

The occurrence of dehiscence and fenestration during orthodontic treatment depends on direction of movement, the frequency and magnitude of orthodontic forces & the volume and anatomic integrity of periodontal tissues. Facial or dental pain can be caused by a fenestration or dehiscence of a tooth root. Sarikaya et al study revealed that some patients exhibited fenestration and dehiscence in the direction of movement[29].

Enhos et al studied the presence of alveolar defects (dehiscence and fenestration) among patients with different vertical growth patterns. Study conducted by Yagci et al. revealed that the Class II group had a greater prevalence of fenestration than the other groups. Although fenestration had greater prevalence in the maxilla, more dehiscence was found in the mandible for all groups[10].

E. GINGIVAL INVAGINATION / INTERDENTAL FOLD

An infolding or invagination of gingival tissue commonly forms during the orthodontic approximation of teeth (Fig. 11)[32].

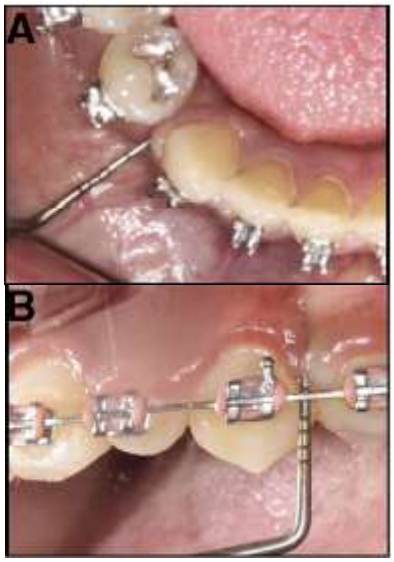

Figure 11. A, Occlusal and B, buccal views of gingival cleft

Available evidence suggests that the risk of gingival cleft formation is greatest when orthodontic space closure begins late after tooth extractions and remodelling of the alveolar ridge occurs. Another hypothesis for the development of gingival clefts is that the transseptal fibre system may be displaced rather than remodelled during tooth movement, resulting in bunching, pressure on the subjacent bone, and concomitant invagination of the gingival tissues[9].

F. OPEN GINGIVAL EMBRASURES/ BLACK TRIANGLES

Open gingival embrasures, also known as ‘‘black triangles,’’ (fig 12) refer to empty spaces below the interproximal contact when the space is not filled with gingiva. Several causes, such as stretching of the interdental transseptal gingival fibres during orthodontic treatment, have been suggested. Open gingival embrasures are most commonly located between the maxillary central incisors.[3]

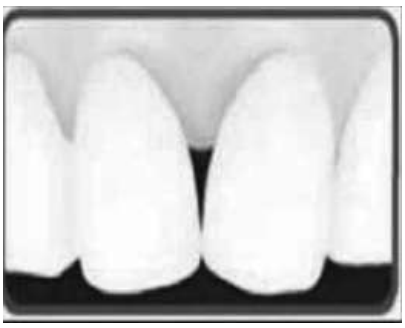

Figure 12

TREATMENT: Papilla preservation during periodontal regeneration surgeries, Papilla reconstruction with tissue grafting influenced by growth factors, Mask the black triangle with filler, restorative approach, laser & orthodontic approach.[24]

3. TMJ DYSFUNCTION

A risk of development of functional problems during orthodontic treatment has been ascribed to a posteriorly directed loading of the TMJ either during or following treatment. Larsson and Ronnerman found TMJ clicking to be the most prevalent sign of dysfunction in their postorthodontic patients.[26] Orthodontic treatment has been variously cited both as a protective and harmful factor in TMD etiology. Class II elastics and maxillary premolar extractions have been implicated as causes of temporomandibular disorders (TMD).[22]

4. **MUCOSAL ULCERATION**

It has been shown that oral pain, oral ulceration, and soft tissue abrasion as well as general well being may be influenced when individuals receive treatment with fixed orthodontic appliances. Kvam, Bondevik & Gjerdet in their study found that about 47% ulcers were caused by the fixed appliances and 38% were caused the most discomfort[17]. Biomechanics involving arch wire loops and utility arches are often required during orthodontic treatment for space closure, space maintenance or intrusion can also cause ulcerations[18]. Chlorhexidine gluconate mouthwash has been shown to reduce traumatic oral ulceration associated with the initial period of fixed appliance wear.

5. RELAPSE

The typical type of orthodontic relapse is well documented and includes crowding or spacing of teeth, return to increased overbite and overjet, and instability of Angle class II and III corrections. Orthodontic relapse is defined as a return toward pre-treatment conditions. Studies evaluating the long-term effect of orthodontic treatment constantly show that 40% to 90% of the patients treated have unacceptable dental alignment 10 to 20 years after retention, with large individual variations[25].

6. GASTROINTESTINAL

Patients receiving orthodontic treatment are at a high risk of having appliances swallowed into the oropharynx during treatment due to the small size of brackets and clipped wires. Orthodontic appliances that can be ingested/ aspirated include: Wires, Brackets, Transpalatal arches, Keys for expanders & Removable appliances

There are many strategies to avoid such accidents during dental procedures- use of rubber dam, use of gauze throat, tying small objects with floss, directly observing the entire procedure, using the most upright

patient position possible and providing detailed instructions to patients (fig 13).
An ingested foreign body may result in: Difficulty or inability to swallow, pain on swallowing, muscle incoordination & hematemesis or vomiting, excessive coughing, difficulty in breathing, choking, congestion, runny nose or watery eyes, dusky-bluish or red changes in the face, on or under the eyes or around the mouth lead to a more morbid condition such as asphyxiation.[19]

7. NICKEL & CHROMIUM ALLERGY

Nickel (Ni)-containing alloys are present in a substantial number and wide variety of appliances, auxiliaries and utilities used in orthodontics. Recent evidence has attributed carcinogenic, mutagenic, cytotoxic and allergenic actions to Ni in various forms and compounds. It has been reported that in vitro release rate for full mouth orthodontic appliances to be 36ug/day for chromium and 40ug/day for nickel. Nickel release from dental alloys have been reported as 4.2 ug/cm^2 per day.

CHROMIUM ALLERGY: Orthodontic bands, brackets and wires universally made of austenitic stainless steel containing approximately 18% chromium and 8% nickel. A study by Lindemann aimed to prove whether cellular in vitro tests are predictive of chromium allergy. The reaction would be stomatitis from mild to severe erythema, loss of taste, tongue soreness, angular cheilitis, allergic contact dermatitis, widespread eczema and exacerbation of preexsisting eczema. Alternatives to prevent nickel & chromium allergy in orthodontics would be use of: Teflon coated (Tooth coloured epoxy resin) wires, Optiflex archwires, Fibre reinforced composite archwires, Beta III Titanium, CNA Beta – Titanium & TMA wires[31]

8. ALLERGY TO BONDING AGENTS

Two monomers are mainly used in orthodontic adhesive resins: bisphenol A diglycidyl dimethacrylate (Bis-GMA) and triethylene glycol dimethacrylate (TEGDMA).[12] The curing system usually involves benzoyl peroxide, a tertiary amine as found in polymethylmethacrylates. Hypersensitivity reactions to polymethylmethacrylates are known to occur yet there are few reported cases of allergy to composite resins.
Ahrari et al evaluated the cytotoxic effects of a No-Mix (Unite), a light-cured (Tranbond XT), and a flowable (Denfil Flow) adhesives on human oral fibroblasts. The results revealed moderate cytotoxic effects of No-Mix adhesive on the first day of the experiment which suggested that care should be taken to protect dentists and patients when these adhesives are being handled[1].

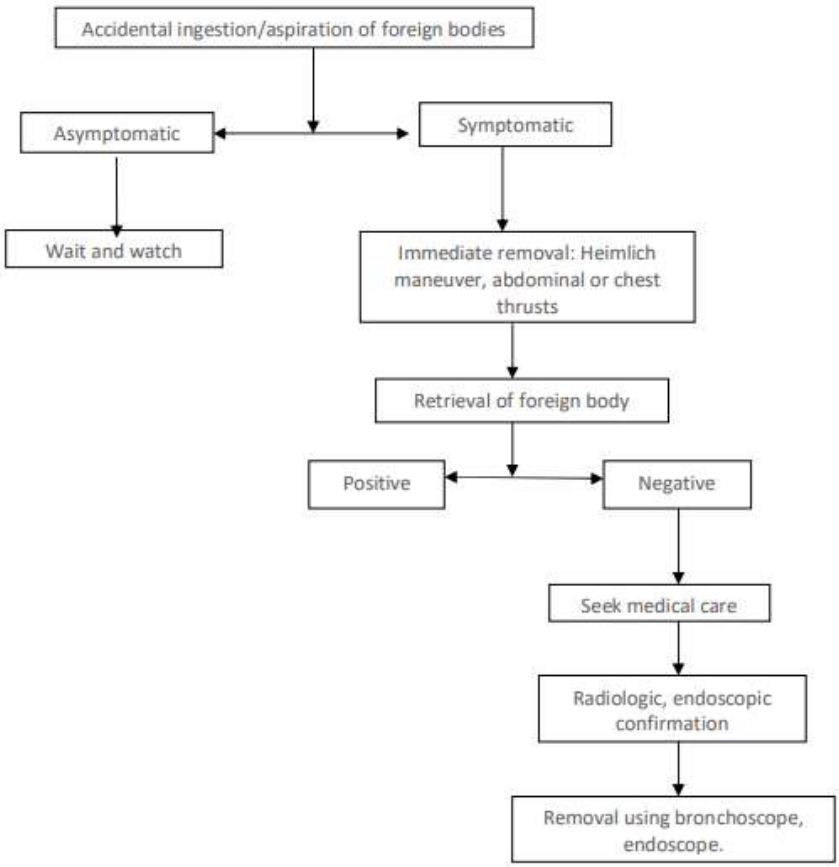

Figure 13. Flowchart for Management of Accidental Ingestion/ Aspiration of a Foreign Body

9. CROSS INFECTION

Orthodontic instruments present special problems, since they have difficulty to clean hinge areas, sharp angles, cutting edges, or pointed ends that can be potentially damaged by corrosion using autoclave sterilizers that use water vapours.

MICROBIAL CONTAMINATION OF "AS RECEIVED" AND "CLINIC EXPOSED" ORTHODONTIC MATERIALS: If orthodontic materials are not provided sterile, should they be sterilized before use[5]

HEPATITIS

HBV - like HIV is a blood borne disease. It causes chronic viral inflammation of the liver and quietly devastates it without the victim realizing anything wrong with him till the damage is in a advanced stage. Hence the title-THE SILENT EPIDEMIC.

Infection control protocols:

1. Vaccination of treating doctor and assistant
2. Thorough medical history and family history of the patient
3. Barrier techniques - gloves, mouth mask. Etc.
4. Sterilization: Field Sterilization and Isolation, Instrument Sterilization, Record Sterilization & Waste Disposal[16]

STERILIZATION TECHNIQUES: Steam sterilization (may cause dulling and decrease the life of some instruments), Chemiclave (chemical vapours), Dry heat sterilization, Hot air oven (HAO), Sterilizers with glass beads

10. ORTHOGNATHIC SURGERY

A. Le-FORT OSTEOTOMIES can cause: Maxillary sinusitis, Loss of tooth vitality, Sensory nerve morbidity, Aseptic necrosis, Vascular complications, nasal septum deviation, unfavourable fractures of the skull base and pterygoid plates, Ophthalmic complications, mispositioning, nonunion, maxilla instability & relapse.

B. SAGITTAL SPLIT OSTEOTOMY can cause: neurosensory disturbance, unfavourable split, infection, excessive bleeding, temporomandibular dysfunction[33] &

CONDYLAR RESORPTION: Condylar resorption (CR) or condylosis can be defined as progressive change of condylar shape with a reduction in mass. Current evidence on CR is not clear but seen more in female with mandibular deficiency and high mandibular plane angle after bimaxillary surgery.

OSTEOTOMY SLIPPAGE: Osteotomy slippage is any decrease in the length from condylion to the lower incisors that occurs at the BSO surgical site before bony union. Osteotomy slippage occurs before osteotomy union in response to para-mandibular connective tissue (PMCT) stretch which produces force that pulls the tooth-bearing fragment posteriorly after advancement (Fig. 14).

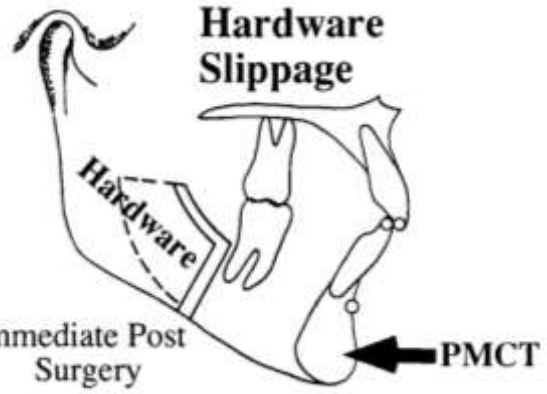

Figure 14: Mandibular advancement stretches the PMCT, producing a potential posterior relapse force (arrow) on the tooth-bearing fragment. Countering the PMCT vector is the condyle, hardware, IMF (wire or elastics), and skeletal suspension, if used.

CONDYLAR SAG: Condylar sag, as used in the literature, infers a condyle that is positioned inferior or anteriorinferior to the glenoid "fossa seated position and, because of this position has no ability to support B point in the advanced position (Fig. 15).

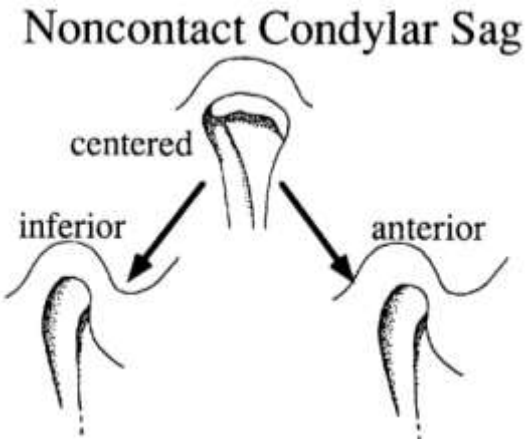

Figure 15. Noncontact condylar sag. In the sagittal plane, NCCS is inferior or anterior-inferior in the glenoid fossa. Frontally, the condyle is centered. The postoperative advanced B point position is not supported by these condyle positions. B point relapse occurs during or at the release of intermaxillary fixation.

CONDYLAR COMPRESSION AND MORPHOLOGIC CHANGE: Compression occurs as either posterior condylar compression (PCC) or medial-lateral condylar compression (MLCC). The PCC is the result of changing the preoperative condyle position to a more posterior position during the surgical procedure (Fig. 16).

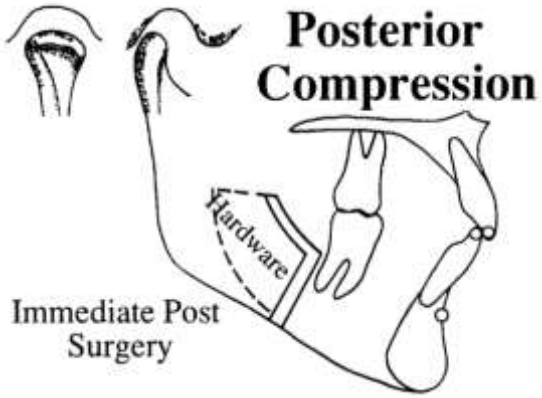

Figure 16. Posterior condylar compression occurs when the condyle is placed posterior-inferior to the preoperative condyle position by the surgeon and/or hardware. The posterior condyle compression provides excellent shortterm support for B point when the hardware is rigid and no osteotomy slippage occurs[4].

C. INTRAORAL VERTICAL RAMUS OSTEOTOMY: During IVRO, inferior alveolar nerve (IAN) damage may occur due to the proximity of the vertical osteotomy to the IAN. Kawase-Koga et al. classified the osteotomy line into three types, namely vertical, C-shaped, and oblique. The most complications occurred in the vertical type cases. Condylar luxation was found mainly in unilateral IVRO cases, and bony interference was found in bilateral IVRO cases. (Figure17).

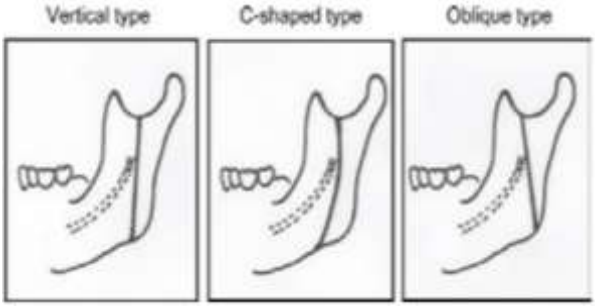

Figure 17. Classification of the shape of the osteotomy line[33]

CONCLUSION

The risks associated with orthodontic treatment are a reality, complications being a result of a multifactorial process, including aspects related to patient, orthodontist and the technical features of orthodontic appliances and procedures. These can be prevented or limited through identification and implementation of best treatment alternative for each individual case. Patient's compliance is an important factor that can contribute to a high standard outcome, with minimum side effects.

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