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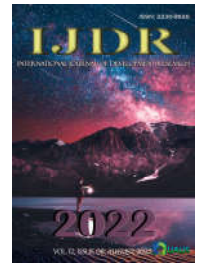
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REVIEW ARTICLE

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## PATHOLOGICAL CONDITIONS OF THE ORAL MUCOSA CAUSED BY ORTHODONTIC APPLIANCES - INTEGRATIVE REVIEW

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### ABSTRACT

Pathological conditions of the oral mucosa, especially non-neoplastic proliferative processes, have a high prevalence in the dental clinic and are usually caused by mechanical trauma of chronic nature with or without the association of microorganisms. Fixed and removable orthodontic appliances may be important etiological factors associated with oral mucosa injury during orthodontic treatment. Brackets, archwires, elastics, bands, and other orthodontic appliances can favor microtraumas in the oral mucosa and, when chronic, predispose the mucosa to pathophysiological changes that can culminate in the formation of a pathological condition. Non-neoplastic proliferative tissue processes, bullous lesions, inflammatory lesions, and ulcerations are alterations that are commonly related to the use of orthodontic appliances and can result in various degrees of morbidity to the patient, in addition to hindering orthodontic management during treatment. The aim of this study was to discuss the relevant aspects related to the main lesions that can affect the oral mucosa due to the use of orthodontic appliances through an integrative literature review.

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## INTRODUCTION

Subjective aspects such as patient discomfort and interdisciplinarity are a part of the individual's treatment and health promotion process (Lima, Gregório *et al.* 2005, Cantekina, Celikoglu *et al.* 2011). In this context, changes in the mucosa arising from orthodontic appliances are of great relevance to orthodontists (Baricevic, Mravak-Stipetic *et al.* 2011). Brackets, wires, and orthodontic bands inevitably promote microtrauma to the lips, buccal mucosa, tongue, and palate (Baricevic, Mravak-Stipetic *et al.* 2011, Cantekina, Celikoglu *et al.* 2011). These frequent and chronic traumas predispose the oral mucosa to different types of pathophysiological changes that can culminate in the formation of a pathological condition (Talic 2011). Tissue reactions are effects commonly related to orthodontic treatment and constitute one of the risks of this therapy (Travess, Roberts-Harry *et al.* 2004). Thus, pain and discomfort are frequent events resulting from irritation caused by the appliances (Kvam, Bondevik *et al.* 1989, Lima, Gregório *et al.* 2005). The trauma caused by fixed and removable appliances stemming from chronic irritation promoted by contact with the mucosal surface or even from the occlusion in modification can result in non-neoplastic proliferative tissue processes, bullous lesions, inflammatory lesions, and ulcerations capable of generating morbidity for the patient and

operative difficulties during treatment (Baricevic, Mravak-Stipetic *et al.* 2011, Perry, Johnson *et al.* 2018). In the current literature, epidemiological studies related to the frequency and types of mucosal lesions associated with orthodontic treatment are scarce (Baricevic, Mravak-Stipetic *et al.* 2011). Traumatic oral lesions are highly prevalent in clinical practice; however, prevention, diagnosis, and treatment of these lesions are sometimes neglected, which can affect patient motivation and duration of the treatment (Lima, Gregório *et al.* 2005, Consolaro and Consolaro 2009). Given the above, the present study's objective was to discuss the relevant aspects related to the main lesions that can affect the oral mucosa resulting from the use of orthodontic appliances through an integrative review of the literature.

## MATERIALS AND METHODS

This integrative review was developed in accordance with PECO strategy: Population – patients undergoing orthodontic treatment; Exposure – orthodontic appliance; Comparison – patients without orthodontic appliance; and Outcome – oral mucosa lesions. The PubMed, Science Direct, Virtual Health Library (VHL), Cochrane, Web of Science, Scielo and Google Scholar electronic databases were searched using the keywords "oral

mucosa”, “inflammation”, “orthodontics” and “pathology” in English and Portuguese. Observational studies that investigated the topic were included in the review. No restrictions were imposed for language or year of publication. Case reports, case series and literature reviews were also considered eligible. In vitro studies, letters to the editor, abstracts from conferences and animal studies were excluded.

## LITERATURE REVIEW

**Orthodontic appliances and mucosal lesions:** Brackets, bands, archwires, and tubes are examples of orthodontic components capable of generating mucosal irritation that often occurs at the beginning of treatment or between treatment sessions (Travess, Roberts-Harry et al. 2004). The continuous friction of the devices can generate local inflammatory processes capable of triggering a series of reactive and immunological events that can culminate in different types of stomatological lesions (Baricevic, Mravak-Stipetic et al. 2011). Inflammatory cells are recruited to the site of irritation to overcome the offending agent and stimulate local repair. In this context, the different cell types related to inflammation release chemical mediators and growth factors to protect the damaged mucosa. However, the inflammatory phenomena can culminate in ulcerative and hyperplastic processes that, at times, can be related to the genesis of several pathological processes (Andrucio, Matsumoto et al. 2019, Hanna, Guerra-Moreno et al. 2019).

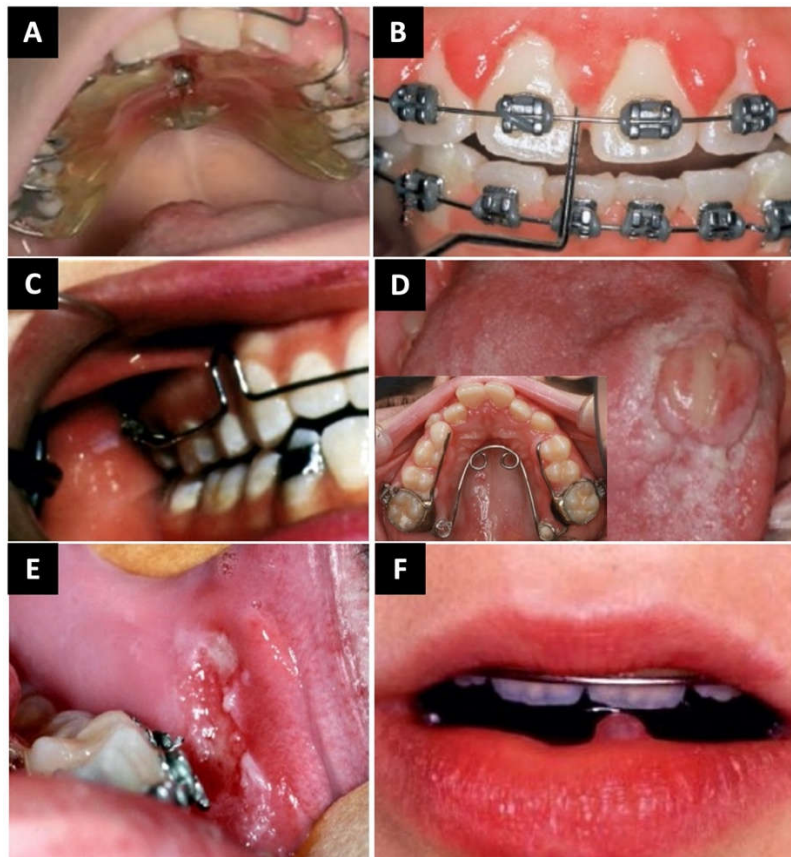
**Non-neoplastic proliferative processes:** Non-neoplastic proliferative processes are clinically characterized by limited, sessile, or pedunculated tissue enlargement, with a color ranging from pink to erythematous, and may or may not have painful symptoms (Gama, De Araujo et al. 2007, Vincent-Bugnas, Borsa et al. 2021). The effects of fixed and removable orthodontic appliances on oral tissues are not yet fully understood, however, mucosal injuries related to orthodontic appliances seem to be highly prevalent (Lima, Gregório et al. 2005). The non-neoplastic proliferative processes associated with orthodontic appliances appear as fibromas, chronic hyperplastic gingivitis, and pyogenic granulomas, characterized by tissue growth resulting from mechanical and/or bacterial irritation of chronic nature (Kvam, Bondevik et al. 1989, Lima, Gregório et al. 2005, Jafarzadeh, Sanatkhani et al. 2006, Gama, De Araujo et al. 2007). Normally, the orthodontic appliance makes it difficult to perform adequate oral hygiene, which contributes to the development of inflammation of adjacent soft tissues as well as to the promotion of proliferative lesions (Baricevic, Mravak-Stipetic et al. 2011). The etiology of non-neoplastic proliferative processes is due to low-intensity chronic trauma, generally represented by inflammation stemming from the trauma of fixed and removable appliances or the difficulty in removing dental biofilm due to these appliances (Travess, Roberts-Harry et al. 2004, Cantekina, Celikoglu et al. 2011).

**Irritation fibroma:** Fibromas are also called irritation fibroma, traumatic fibroma, focal fibrous hyperplasia, or fibrous nodule (Thompson 2006) and correspond to a proliferative response of the fibrous connective tissue of the oral mucosa to a low-intensity local traumatic irritant, such as orthodontic appliances (Esmeili, Lozada-Nur et al. 2005). According to the World Health Organization (WHO), the histopathological characteristics of these lesions reveal a mass of dense fibrous connective tissue, covered by stratified squamous epithelium, which sometimes may present areas of papillary atrophy and superficial hyperkeratosis. The presence of chronic inflammatory infiltrate completes the histopathological scenario (Thompson 2006). Fibromas are formed by epithelial and connective enlargement that projects in a pedunculated or sessile way into the oral cavity. Although irritating fibroma can occur anywhere in the mouth, the buccal mucosa is the most prevalent site of involvement (Gonsalves, Chi et al. 2007). The size of the lesions can vary from a few millimeters in diameter to up to centimeters in their largest diameter (Dutra, Longo et al. 2019), and they clinically present as well-defined, circumscribed nodules of normal color, firm consistency on palpation, and no painful symptoms (Lapitskaya, Cahuana-Bartra et al. 2022).

Treatment for irritating fibroma is the surgical removal of the lesion using excisional biopsy, with concomitant removal of the etiologic irritant factor (Al-Khateeb 2009). Recurrences of fibromas are uncommon; however, they may occur due to failure to eliminate the etiologic agent associated with the lesion (Figure 1A). The excised tissue must be referred to a pathological microscopy service to obtain a definitive diagnosis (Baricevic, Mravak-Stipetic et al. 2011).

**Hyperplastic chronic gingivitis:** Chronic hyperplastic gingivitis or inflammatory gingival hyperplasia is characterized by an increase in generalized or localized gingival tissue, usually initiated by the papillae and associated with gingivitis, which conceptually consists of gingival inflammation limited to the soft tissues surrounding the tooth (Gama, De Araujo et al. 2007, Gonsalves, Chi et al. 2007). The accumulation of biofilm on the surfaces of the appliances, associated with poor hygiene, configures the main etiological factor of gingivitis in orthodontic patients (Barack, Staffileno et al. 1985, Asnaashari, Azari-Marhabi et al. 2013). The histopathological features of gingival hyperplasia evidence a mild inflammatory infiltrate composed of an increase in the number of polymorphonuclear leukocytes that accumulate in the connective tissue adjacent to the epithelium. Areas of fibrosis, hyperemia, edema, and hemorrhage complete the histological scenario (Thompson 2006). In addition to well-established factors, other events such as microbiological susceptibility, smoking, diabetes, and drug use may be related to gingival inflammatory processes (Krishnana, Ambilib et al. 2007). The initial signs of gingivitis include loss of gingival stippling, light bleeding on manipulation or probing, flaccid consistency, reddish color, and blunt margins (Florman 2007, Eid, Assiri et al. 2014) (Figure 1B). With the chronicity of inflammatory phenomena, the gingival tissue may present a significant increase in its tissue components, resulting from edema and hyperplasia of the epithelial and connective tissues of the mucosa, leading to chronic hyperplastic gingivitis (Closs, Branco et al. 2007, Asnaashari, Azari-Marhabi et al. 2013, Eid, Assiri et al. 2014). The treatment of chronic hyperplastic gingivitis is based on the eradication of the etiologic agent, when possible, or control of events that increase the susceptibility to the installation of the lesion. Bacterial plaque control performed by the patient and professional prophylactic follow-up are measures to control the pathology (Barack, Staffileno et al. 1985, Gama, De Araujo et al. 2007, Eid, Assiri et al. 2014). In some cases, after improved hygiene, surgical procedures may be necessary to remove the excess fibrous tissue and provide a better gingival contour (van Beek 2009).

**Pyogenic granuloma:** Pyogenic granuloma is a non-neoplastic proliferative process in which its etiopathogenesis is based on trauma and local irritation (Al-Khateeb 2009, Gordon-Nunez, de Vasconcelos Carvalho et al. 2010, Krishnapillai, Punnoose et al. 2012). Biofilm, dental calculus, gingival inflammation, and hormonal changes during pregnancy and menarche are also important etiological factors (Epivatianos, Antoniadis et al. 2005). This condition is characterized as a reactional and slow proliferative tissue growth lesion, consisting of granulation tissue and intense vascularization, with a smooth or lobulated surface, with occasional areas of ulceration, without painful symptoms and eventually bleeding on palpation (Jafarzadeh, Sanatkhani et al. 2006). It is more prevalent in children and young adults, although it can affect people of all ages and often pregnant women (Gordon-Nunez, de Vasconcelos Carvalho et al. 2010, Krishnapillai, Punnoose et al. 2012). The main site of involvement of pyogenic granuloma is the gingiva (75%). The irritation and gingival inflammation resulting from poor hygiene and/or orthodontic appliances configure predisposing events for the pathology (Figure 1D) (Epivatianos, Antoniadis et al. 2005, Jafarzadeh, Sanatkhani et al. 2006). However, any region of the oral mucosa such as lips, tongue, buccal mucosa, and palate is susceptible to this lesion (Gordon-Nunez, de Vasconcelos Carvalho et al. 2010). Clinically, pyogenic granuloma presents as an exophytic soft tissue mass, with moderate to rapid growth, with a sessile or pedunculated base, well delimited, erythematous or purple, and with a bleeding tendency.



**Figure 1. Pathological conditions of the oral mucosa caused by orthodontic appliances. A) Erosion on the tongue (Baricevic, Mravak-Stipetic *et al.* 2011); B) Gingival hypertrophy (Krishnana, Ambilib *et al.* 2007); C) Hyperkeratosis on the buccal mucosa (Bishara 1995); D) Pyogenic granuloma on the tongue (Acharya, Gill *et al.* 2011); E) Aphthous ulceration on the buccal mucosa (Consolaro and Consolaro 2009); F) Mucocele on the lower lip (Rose and Rose 2004)**

Spontaneous painful symptomatology is absent, however, when stimulated, it may be noticeable (Al-Khateeb 2009, Gordon-Nunez, de Vasconcelos Carvalho *et al.* 2010, Acharya, Gill *et al.* 2011). In the histopathological examination, it is possible to observe the increase of vascular structures obliterated by red blood cells accompanied by an intense inflammatory infiltrate with areas of fibrosis completing the microscopic scenario (Thompson 2006). Surgical excision is the treatment of choice for pyogenic granuloma lesions combined with the removal of local irritating factors, such as basic periodontal therapy, crown polishing, removal or adaptation of orthodontic appliances, and oral hygiene guidance (Acharya, Gill *et al.* 2011).

**Hyperkeratosis:** Hyperkeratosis is characterized by a whitish alteration of the mucosa that can evolve into a non-detachable white plaque, with an irregular and torn surface that may present ulcerated components in its constitution. Local traumatic irritation is the main etiological factor associated with focal hyperkeratosis (Bishara 1995, Thompson 2006, Baricevic, Mravak-Stipetic *et al.* 2011). The term hyperkeratosis is a histopathological denomination defined by the increase in the thickness of the stratum corneum (Handley and Ogden 2006). The thickening of the keratin layer on the surface of the mucosal lining epithelium occurs at the expense of low-intensity local irritation for a relatively long period, such as unsatisfactory occlusion, parafunctional habits, and prosthetic and orthodontic appliances (Baricevic, Mravak-Stipetic *et al.* 2011). The main site of involvement of this condition is the buccal mucosa, however, any region of the mouth can be subject to this alteration, if the traumatic agent is present (Lima, Gregório *et al.* 2005) (Figure 1C). Upon microscopic examination, it is possible to observe areas of epithelial hyperkeratosis with the presence of lacerations and keratin projections (Thompson 2006). Most irritative focal hyperkeratoses do not require treatment and normally no complications arise from this condition. However, it is necessary to identify the irritating agent and eliminate it, followed by clinical follow-up of the patient and

verification of lesion regression. The correct differential diagnosis must be performed to exclude other pathological conditions that also present as white spots/plaques (Florman 2007, Consolaro and Consolaro 2009, Cantekina, Celikoglu *et al.* 2011).

**Aphthous ulcerations:** Aphthous ulcerations are highly prevalent pathological conditions in the population. About 70% of the population has episodes of canker sores (Kvam, Bondevik *et al.* 1989). The genesis of this lesion is based on the immune response mediated by T cells, which would be oriented towards epithelial destruction by the process of cytotoxicity (Consolaro and Consolaro 2009). Aphthous ulcers can affect any region of the oral mucosa, however, non-keratinized mucosa is a more prevalent area due to the reduced epithelial thickness and lack of superficial tissue protection (Gonsalves, Chi *et al.* 2007). Clinically, the lesions are characterized by focal loss of epithelial integrity, with an erythematous or yellowish color (fibrinopurulent membrane) with a reddish halo and painful symptoms (Messadi and Younai 2010) (Figure 1E). The initiating factors associated with canker sores have not yet been fully clarified. Allergies, genetic predisposition, nutritional deficiencies, hematological abnormalities, hormonal influences, infectious agents, mucosal trauma, and stress seem to be events associated with the genesis of this lesion (Consolaro and Consolaro 2009). Canker sores resulting from orthodontic treatment are related to microtraumas to the lips, buccal mucosa and lingual margins caused by brackets, arches, bands, elastics, and other orthodontic appliances capable of generating mucosal trauma (Bishara 1995, Travess, Roberts-Harry *et al.* 2004, Baricevic, Mravak-Stipetic *et al.* 2011). Aphthous lesions can be divided into three types: (1) minor aphthous ulcerations, which are superficial lesions that measure from 1 to 10 mm in diameter and have a clinical course of 7 to 14 days; (2) the larger ones are characterized by extensive and deep ulcers that measure between 1 and 3 cm in diameter and can evolve in about 2 to 6 weeks, commonly causing scarring on the mucosa; (3) herpetiformis, which are multiple lesions that have a high frequency of recurrence and

measure between 1 to 3 mm, similar to herpes lesions (Consolaro and Consolaro 2009, Messadi and Younai 2010). The treatment of canker sores is directly related to the relief of painful symptoms and the reduction of the duration of the ulcers (Kvam, Bondevik *et al.* 1989, Gonsalves, Chi *et al.* 2007, Messadi and Younai 2010). The usual clinical approach is to advise the patient to avoid perforating, acidic or astringent foods and to use waxes to protect the orthodontic appliances (Consolaro and Consolaro 2009), in addition to prescribing an oral corticosteroid ointment to apply on the lesions (Lima, Gregório *et al.* 2005).

**Mucoceles:** Mucoceles are lesions that have no predilection for gender or age, however, they commonly affect children and young adults (Al-Khateeb 2009, Re Cecconi, Achilli *et al.* 2010). The most common site of involvement of mucocele is the lower lip, accounting for 60% of cases (Esmeli, Lozada-Nur *et al.* 2005). Its occurrence is the result of rupture or obstruction of the duct of a minor salivary gland with consequent spillage of mucin into the tissues or retention of this fluid inside the gland due to trauma, and the use of orthodontic appliances predisposes the appearance of this pathology (Re Cecconi, Achilli *et al.* 2010). Clinically, the lesions present as swellings of the mucosa in the form of a bubble or dome of variable size (from 1 to 10 mm), asymptomatic, with a circumscribed shape, a smooth surface, with a floating consistency on palpation, and a color similar to that of the mucosa, translucent or bluish. Eventually, the lesions may rupture and generate superficial ulcerations (Rose and Rose 2004)(Figure 1F). On microscopic examination, the mucocele shows areas of mucin extravasation and is surrounded by granulation tissue and salivary glands. A conical inflammatory infiltrate completes the histopathological scenario (Thompson 2006). The treatment of mucocele is performed from the surgical enucleation of the gland affected by the pathology. Another course of treatment for mucoceles is called micro-marsupialization, performed by passing a suture through the center of the lesion, thus allowing the extravasation of the mucous content and regression of the alteration (Rose and Rose 2004, Re Cecconi, Achilli *et al.* 2010).

## DISCUSSION AND CONCLUSION

The risks associated with the use of orthodontic appliances include changes in phonetics, irritation of the mucosa, modification of the occlusion due to tooth movements, and predisposition to diseases such as caries and periodontal disease (Bishara 1995, Travess, Roberts-Harry *et al.* 2004, Florman 2007, Acharya, Gill *et al.* 2011, Baricevic, Mravak-Stipetic *et al.* 2011). The study by Kvam *et al.* showed that among users of fixed orthodontic appliances, 75.8% of the patients had some type of mucosal lesion, and of these, 2.5% had large pathologies with exacerbated symptoms (Kvam, Bondevik *et al.* 1989). Others studies have also described the high prevalence of mucosal lesions in patients with orthodontic appliances and reported that they can range from small ulcerations to large tumors (Travess, Roberts-Harry *et al.* 2004, Lima, Gregório *et al.* 2005, Baricevic, Mravak-Stipetic *et al.* 2011). The predilection sites for lesions caused by orthodontic appliances are the buccal mucosa, lower lip, and the cul-de-sac, regions that are in close contact with the orthodontic components (Bishara 1995, Travess, Roberts-Harry *et al.* 2004, Baricevic, Mravak-Stipetic *et al.* 2011). In users of removable appliances, mucosal lesions are also frequent findings (Rose and Rose 2004, Acharya, Gill *et al.* 2011). Inflammation of the palatal mucosa and trauma to tongues commonly arise from palatal screws and wires incorporated into the appliances, in addition to the predisposition to fungal infections (Travess, Roberts-Harry *et al.* 2004, Acharya, Gill *et al.* 2011). In this context, it is important that the orthodontist uses adequate and adapted orthodontic components to minimize trauma to the mucosa and prevent injuries. The use of waxes in orthodontic appliances to protect the mucosa is an interesting preventive strategy against mucosal trauma (Kvam, Bondevik *et al.* 1989, Florman 2007). Another relevant point is oral hygiene instruction because, in addition to caries and periodontal diseases, unsatisfactory hygiene can contribute to the genesis of proliferative pathological processes (Acharya, Gill *et al.* 2011, Baricevic, Mravak-Stipetic *et al.* 2011). It

is important to emphasize that there is a scarcity of studies in the literature about mucosal lesions related to orthodontic appliances (Baricevic, Mravak-Stipetic *et al.* 2011). Studies related to materials engineering with a focus on injury prevention are practically non-existent and these could be of great contribution to orthodontic clinical practice. The knowledge of the orthodontist about the oral pathological processes is of great importance for the correct management of the patient. The history of the pathological event added to the clinical findings can provide a better treatment approach for the patient and determine more accurately the dental specialty to be referred to (Stomatology, Periodontics, Oral and Maxillofacial Surgery, among others). The differential diagnosis of pathological changes is also an important step in the process of identification and management of lesions, as it aims to stratify the diagnostic possibilities and consequent exclusion of other diseases, which culminates in the improvement of the approach and the correct referral of the patient. Thus, knowing the pathological processes and forms of management can contribute to reducing patient morbidity and to better acceptance of orthodontic treatment.

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