MDJ

Surface changes of orthodontic brackets following treatment with fixed orthodontic appliances

Dr. Shahba'a A. Mohammed M.Sc. B.D.S
Dr. Abeer B.Mahmoud M.Sc. B.D.S

Abstract

Fixed orthodontic appliances were used for long period in the treatment of malocclusion patients. It is subjected to the oral environment and affected by the changes that take place in this media. Many studies were done and express the tendency of these appliances to corrode inside the mouth.

150 orthodontic brackets related to three different companies (Orthodent, Ortho-organizers, and Dentaurum). These brackets examined after removing them from the patients' mouth and examined microscopically.

Most of the brackets exhibit corrosion which is mainly pitting, crevice and erosion corrosion.

Keywords: surface changes of orthodontic brackets.

Introduction

Orthodontic brackets, bands, and wires are universally made of austentic stainless steel composed of approximately 18% chromium and 8% nickel, in addition, nickel -titanium alloy used as orthodontic arch wires and represent another source of patient exposure to metal corrosion products. The oral cavity is ideal for the biodegradation of metal because of its ionic, thermal, microbiologic and enzymatic properties, some level of patient exposure to the corrosion products of these alloys could be assumed, if not assured. Presently there is little information on the biodegradation of orthodontic appliance in vitro and even less on how much of these biodegradation products are actually affect the patient[1].

Electrochemical corrosion is the principle type in the oral cavity; it looks as an electrochemical cell. The anode is the site where the positive ions are formed while the cathode represents the site at which the free electrons of the anode were consumed (Fig.l). The larger the cathode and the smaller the anode was the greater destruction[2],

Allergic response to nickel containing alloy have been reported in several studies [3]. On the other hand, there is some reports no reaction to nickel containing appliances in nickel sensitivity patient [9,10]. Making establishment of causation was difficulty.

Chromium can form stable oxide layer adheres to the surface and thus protect the stainless steel from the corrosion process but chromium itself can cause dermatitis [1].

In vitro examination of orthodontic

appliances reveals that orthodontic appliances are tend to corrode in artificial saliva[4], and in sodium chloride solution [5]. The types of corrosion in these studies involved galvanic, pitting, crevice, and intergranular corrosion. Lorenzo Faccioni et al, found that nickel, chromium, and cobalt released from fixed orthodontic appliances can induce DNA damage in the oral mucosal cells and these cells contains high concentration of nickel and chromium than the cells of normal patient who did not treated with fixed orthodontic appliance [14]. Maijer and Smith found that there is a development of green and black stains with directly bonded stainless steel brackets inside the patient mouth, they also found that these stains present at one corner of the bracket and also found some voids in the resins and pitting corrosion in the mesh of the brackets Gwinnett found the same results and he suggest that chromium; nickel and iron were present in significant amount in the resin [6,7,8]. It was found that the chromium oxide layer can't be established in the presence of chloride ion solution, difference in the concentration of oxygen, difference in pH, temperature and presence of microorganism [9,10,11].

The purpose of this study was to examine the orthodontic brackets related to three different companies (Ortho-organizers, Dentaurum, Orthodent) after removing the appliances from the patient mouth to detect the corrosion areas and the type of corrosion.

Materials and methods

Austenitic stainless brackets related to three different manufactures used in this study. These brackets were belonged to Ortho-organizers comp. (USA), Orthodent comp.(Canada), Dentaurum com. (Germany). The examined brackets were standard edgewise bracket (0.22 x 0.030 slot). The percentage of the different elements used in making these brackets considered to be a trade secrete for the manufacturing companies. Fifty brackets from each company were examined. These brackets were debonded within 14 days, the brackets debonded from fifteen patient (ten brackets from each patient) and all the patients was caries free or have simple class I amalgam fillings the brackets first examined by the microscope to detect perfectly the areas of rusting and the stagnation areas of the brackets and then the resin was dissected away from the base of the brackets using plastic instrument, the brackets washed using distilled water, dried through a grade series of alcohol (30 - 100 percent) for 5 seconds, immersed in acetone (Volatine organic solvent) for 8 - 10 seconds, and then stored in closely packed glass container contains silica gel particle to avoid any oxidation of the brackets, the bracket re -examined with the microscope.

The examined brackets were obtained from orthodontic patient subjected to treatment for 18 - 24 months and were treated using different types of arch wires (0.014 Ni-Ti; 0.014, 0.016, 0.018, and 0.018 x 0.025 stainless steel wires). The brackets examined with special optical microscope supplied with camera system (photomicrographic system - Model PM 10 AO-Japan).

Results

The examination reveals that 46 orthodontic bracket related to Ortho-organizer company, 48 related to Dentaurum company, and 45 related to Orthodent company exhibit corrosion.

The result of microscopical examination indicates that the most stagnation areas in the bracket were the slot of the bracket, region of the bracket bounded between the inner side of the wings and the base of the bracket, and the borders of the bracket base, food debris and rust manly accumulated at these regions. Fig.2 debonding the resin and cleaning the brackets and re-examination of the same examined bracket reveals that the stagnation areas were more affected by corrosion attack than the other sites. Pitting corrosion can be seen simply on the outer surface of the wings of the brackets (Fig.3) areas of the an extensive pitting and crevice corrosion can be seen obviously at the slot of the bracket (Fig.4), inner side of the wing, the areas bounded by the wing and the base of the bracket (Fig. 5), and at the borders of the base of the bracket (Fig.6) Green, brown, and black precipitate can be seen at the mesh of the bracket (Fig.7,8)

Discussion

In general, it is clear that the oral environment was very complicated, it is subjected to changes in the temperature, the part of the metal which is subjected to the higher temperature could be anodic (corrode) more than the other parts(12,13,14). Difference in the pH inside the mouth can also assist corrosion because corrosion cell can be develop between the zones exposed to the differing solution digestion of food and brushing can remove the protective oxide film exposing the fresh metal to corrode (erosion corrosion), all these make the external side of the bracket more affected than the inner side the pitting corrosion presents in these appliances is mainly due to the presence of chloride ion in the saliva which tend to destroy chromium oxide layer and migration of chloride ion to this fractured oxide areas so this part behaves anodically in comparison to the adjacent protected surface which behaves cathodically (remains intact), this mechanism can be enhanced due to the presence of micro - organism in the mouth which absorb the hydrogen from the surface of steel and thus remove the hydrogen as a resistance factor from the corrosion cell (Fig.9) and this is agree with Miller(15,16)

$$2H_{(aqu)} + 2e^-_{(metal)} \rightarrow H_2 \text{ gas}$$

The stagnation areas were affected by extensive pitting and crevice corrosion is mainly due to differential aeration in these areas (slot, inner side of the wing, and the area between the wing and the base). Oxygen depletion will take place because of the accumulation of debris and the presence of microorganism which cause obstruction on the surface, so no further oxygen reduction occurs and more dissolution of the metal in these areas and production of positive charges which balanced by the migration of chloride ion to the shielded areas and oxygen reduction on the adjacent areas so that the neighboring areas were protected while the shielded areas enlarged (Fig. 10). Additionally the slot of the bracket subjected to wires with different alloys which differ in potential than the stainless steel of the bracket and this lead to electrical cell with more corrosion and destruction to the less potential alloy.

The corrosion at the mesh was mainly due to cracks in the bonding at the mesh side which lead to stagnation areas and crevice corrosion brown and black precipitate represent ferrous and ferric oxide which are punched out due to the destruction of chromium oxide layer and difficulty of its re - establishment since the area is extremely not aerated compared to the rest of the bracket facing the oral cavity leading to small anode (mesh of the bracket) and large cathode (the rest of the bracket) so huge destruction in this area. The green precipitate represents nickel oxide which is pushed to the surface due to the presence of corroded areas and destruction of chromium oxide (Fig. 11).

The overall findings are agree with the previous studies which done in vitro about the type of corrosion for the orthodontic brackets.

References

1- Barrett RD, Bishara SE. Biodegradation of orthodontic appliances, Part I. Biodegradation of nickel and chromium in vitro. Am J Ortho. 1993; 103(1): 8-12.

2- Fisher A. Contact dermatitis, Philadelphia, leg and Febiger. Pd.2

3- Blanlco - Dalmau L, Carrasquillo -Berty E. A study of nickel allergy. J. Pros. Dent. 1984; 52: 116-9.

4- AL- Jobory H. The corrosion behavior and the biological effect of fixed orthodontic appliances in artificial saliva solution (thesis). P.5.

5- Espana A., Alonso M, Soria C. Chronic urticaria after implantation of two nickel containing dental prosthesis in nickel allergic patient, contact dermatitis. 1989; 21:204-6.

6- Maijer R, Smith DC. Corrosion of orthodontic bracket bases. Am J Ortho. 1982; 81(1): 43 -45.

7- Romaguerc C, Vilaplana J, Grimalt F. Contact stomatitis form dental prosthesis, contact dermatitis. 1989;21:204-6.

8- Marigo M, Moyer D, Genelhu M. Evaluation of immunological profile in patients with nickel sensitivity due to fixed orthodontic appliance. Am J Ortho. 2003; 124(1): 46-52.

9- Magnusson B, Bergman M, Bergman B. Allergic from dental alloys, scand. J. Dent. Res. 1982; 90:163-7.

10- Nielsen C, Klaschker F. Ekzemallergikern dtsch Zahn -Mundkeifercheilkd, 1971; 57: 201 -18.

11- Temesvari E, Racz I. Nickel sensitivity from dental prosthesis, contact dermatitis, 1988; 18: 50 -64.

12- Espana A., Alonso M, Soria C. Chronic urticaria after implantation of two nickel containing dental prosthesis in nickel allergic patient, contact dermatitis. 1989; 21:204-6.

13- Park H, Shearer T. in vitro release of nickel and chromium from simulated orthodontic appliances. Am J Ortho. 1983; 84(2): 156-8.

14- Maijer R, Smith DC. Biodegradation of orthodontic bracket system. Am J Ortho. 1986; 90 (3): 195-8.

15- Faccioni F, Franceschetti P, Cerpelloni M. In vivo study on metal release from fixed orthodontic appliances and DNA damage in oral mucosal cell. Am J Ortho. 2003; 124(6): 687-94.

16- Moffa J, Beck D, Hok W. Allergic response to nickel containing dental alloy. J. Pros. Dnet.1977; 56: 78.

17- Gwinnett A. Corrosion of resin bonded orthodontic brackets. Am J Orthod. 1982; 81(1): 201 - 6.

18- Fontana MG, Greene ND. Corrosion engineering, 2nd edition. New York: Mc Graw - Hill book company; 1978:40-61.

19- Miller JD. Microbial aspect of metallurgy, 3rd edition. London: Medical and technical publishing company; 198140-55.

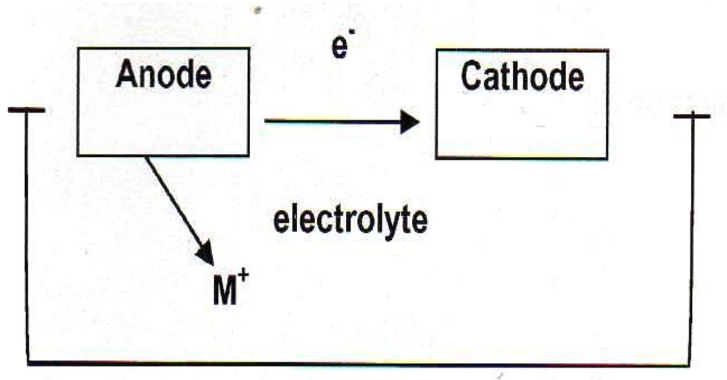


Fig. (1) Electrochemical cell

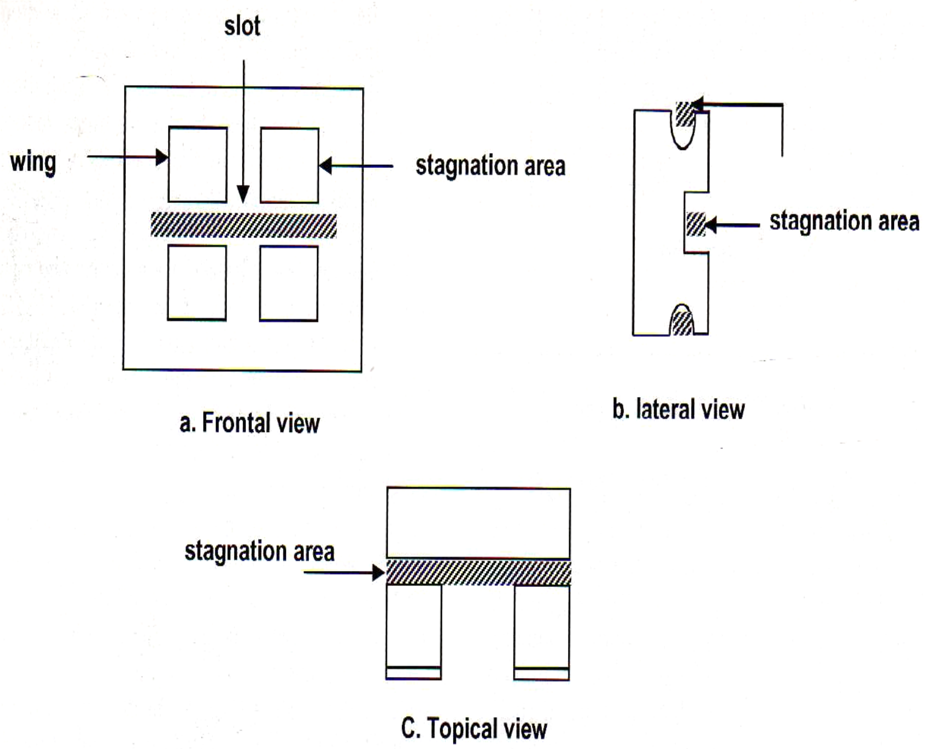
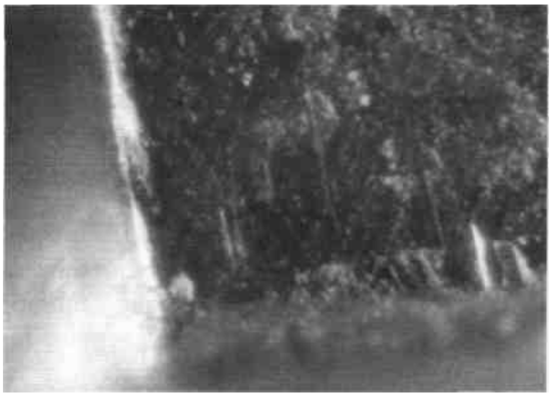
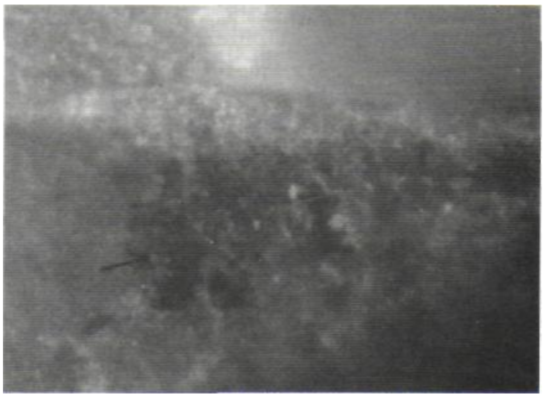


Fig. (2): a,b,c Diagrams represents stagnation area of the brackets



Fig{3); Pitting corrosion at th» wing of the backet



Fig,(4): Corrosion at ttw slot

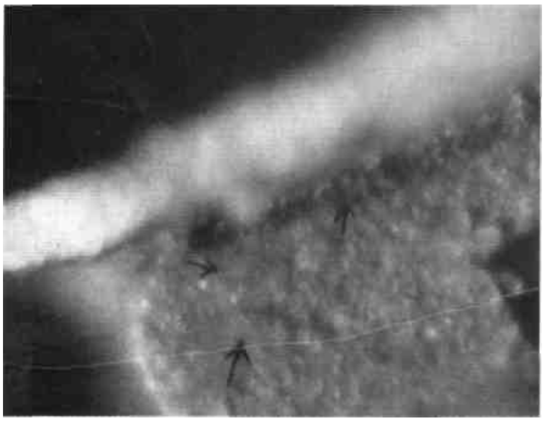


Fig.(5); Corrosion at the inner side of the wing and between the wing

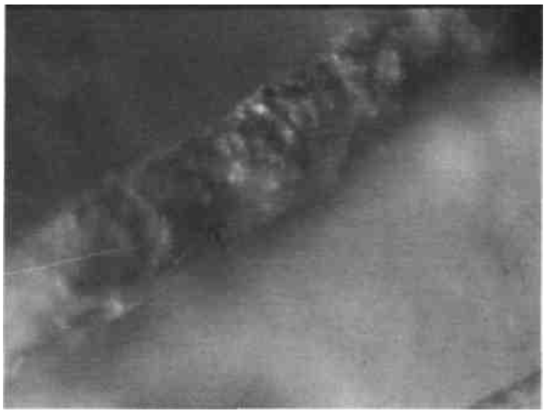
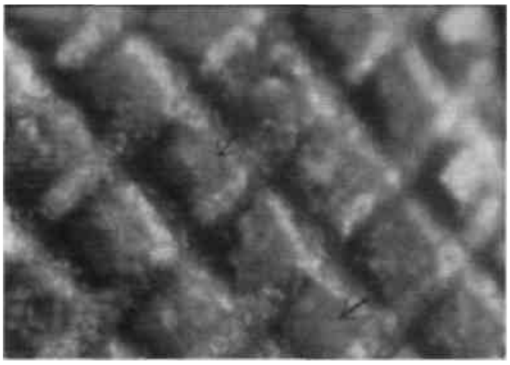


Fig.(6)' Corrosion at the borders of base of the bracket



Flg.(7): Gree and Brown precipitate at the mesh of the bracket

Fig. (8): Black precipitate at the mesh of the bracket

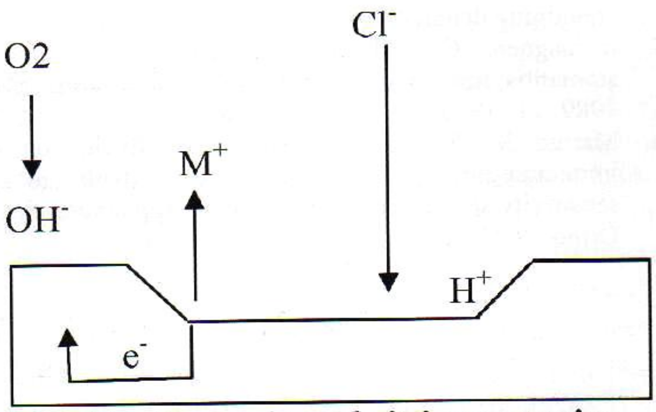


Fig. (9): Mechanism of pitting corrosion

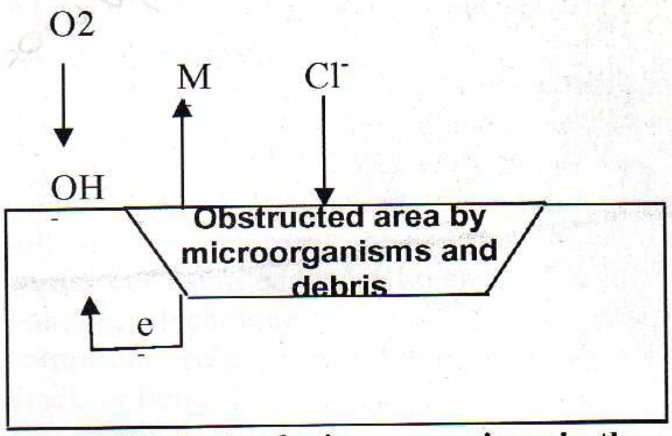


Fig. (10): Role of micro-organisms in the development of corrosion

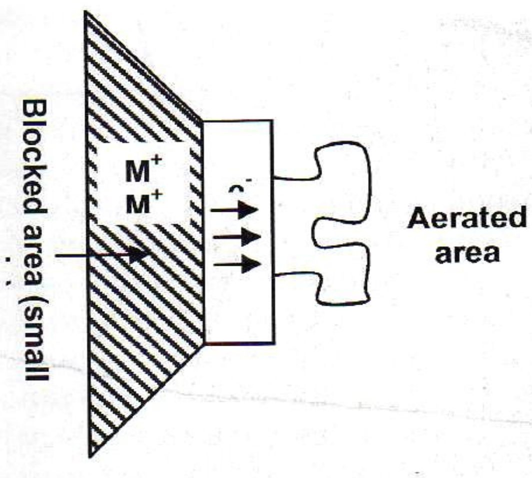


Fig. (11): Corrosion at the mesh of the bracket