Objectives: The purpose of the present study was to investigate the incidence of dental caries during fixed orthodontic treatment and the effect of gender, ethnicity, age at start of treatment, duration of treatment and frequency of oral hygiene instructions on the incidence of dental caries.

Materials and Method: The retrospective study was conducted using selected orthodontic patient records \( \text{n}=115 \) from 2017-2018. Records of new carious lesions which developed during the treatment process were identified. Number of caries and the teeth they are located were recorded. Independent variables were collected by chart abstraction.

Results: Gender, ethnicity, age at the start of treatment and duration of treatment were not significantly associated with caries development.

Conclusions: The incidence of dental caries in patients treated with fixed orthodontic appliances were moderately high. This problem warrants significant attention from both patients and providers that should result in increased emphasis on oral hygiene reinforcement and effective caries preventive measures. The risk of developing caries lesions during orthodontic treatment should not be underestimated by both orthodontists and patients.

Keywords: Dental Caries, Oral Health, Orthodontic Treatment

INTRODUCTION

Dental caries is one of the complications of orthodontic treatment. Caries is a reversible multifactorial process of tooth demineralization and remineralization. It's also known as tooth decay or disease where bacterial processes damage hard tooth structure. These tissues progressively break down, producing dental caries i.e. cavities. Two groups of bacteria are responsible for initiating caries: Streptococcus mutans and Lactobacillus. If they are left untreated, the disease can lead to pain, pulp necrosis and tooth loss. (Chang, Walsh & Freer, 1997; Sukhia, Ayub & Gandhi, 2006).

Caries or enamel decalcification is a serious problem for orthodontic patient as shown by previous records suggested high prevalence of caries in patients receiving fixed orthodontic treatment (FOT), with the cause being difficulty and negligence in oral hygiene maintenance (McGuinness, 1992). In orthodontics, caries usually occurs on smooth surfaces, affecting 2 to 97% of all orthodontic patients (Gontijo, Cruz Rde & Brando, 2007; Boersma, 2005). Orthodontic patients can find it difficult to maintain adequate oral hygiene around fixed appliances. The decline in oral hygiene that often accompanies orthodontic treatment might lead to an increased risk for development of caries lesions. The severity of the resultant dental caries can range from development of opaque WSL, or decalcification, to loss of surface integrity of enamel and cavitation (Gorelick, Geiger & Gwinnett, 1982; Mizrahi, 1982; Richter et al., 2011).

Orthodontic appliances physically alter the microbial environment (Balenseifen & Madonia, 1970; Bloom & Brown, 1964; Corbett et al., 1981; Mattingly et al., 1983; Rosenbloom & Tinanoff, 1991; Scheie, Arneberg & Kroghstad, 1984). Increased proliferation of the facultative bacterial population, including Streptococcus mutans, leads to a decrease in pH that tips the demineralization-remineralization balance toward mineral loss.
(demineralization), which in turn can lead to WSL development and eventually to cavitation and caries extending into the dentin (Chatterjee & Kleinberg, 1979; Pinkham, 1989; Featherstone, 2003; Featherstone et al., 2007).

The present study was designed to investigate the dental caries incidence during FOT and the effect of gender, ethnicity, age at start of treatment, duration of treatment and frequency of oral hygiene instructions on the incidence of dental caries. This study sought to aid orthodontists to be aware of the caries incidence and to decide whether current preventive therapy provided is adequate. The result of this study can help to emphasize the need for good oral hygiene instructions, motivation and meticulous caries-prophylactic measures such as professional tooth cleaning and topical fluoride application during the FOT process.

**RESEARCH METHODOLOGY**

Ethical approval for this study was obtained from Medical Review & Ethics Committee (MREC) Malaysia (NMRR-19-541-46467). One hundred fifteen patient records were selected by applying the inclusion and exclusion criteria from patients treated in the Orthodontic Clinic in the Petrajaya Dental Clinic between 2017 and 2018.

Inclusion criteria for record selection consist of patients who (1) underwent comprehensive orthodontic treatment with full fixed appliances on labial tooth surfaces; (2) had all fixed orthodontic treatment completed (debonded) in 2017-2018; (3) had no dental structural abnormalities, veneers, or other reconstructions; (4) had complete treatment log information in their charts.

Exclusion criteria for record selection consist of patients (a) with ongoing fixed orthodontic treatment; (b) who underwent removable orthodontic appliance treatment only; (c) whose appliances were removed prematurely before completion of orthodontic treatment; (d) who were transferred from other orthodontic specialist clinic (transfer case).

Data collection from deidentified patient charts included gender, race, age at initiation of orthodontic treatment and treatment length. Treatment length was defined as the period between the start of full fixed appliance therapy and the removal of all active fixed appliances. A limited phase 1 treatment before comprehensive treatment was not included in treatment-time calculation. Frequency of oral-hygiene instructions after the initial oral hygiene instructions was recorded from progress notes in the chart. From the patients' charts, records of new carious lesions which developed during the treatment process were identified. Number of caries and the located teeth were recorded.

Statistical analysis was done by using SPSS version 16.0. The statistical analysis including frequency distribution, cross tabulation and chi-square test was used to find the association between dental caries and gender, race, age group, treatment length and frequency of oral hygiene instructions, and the p-value was set at p<0.05.

**RESULTS**

The present study comprised of 115 orthodontic patients including 82 (71.3%) females and 33 (28.7%) males. The age of the subjects ranged from 12 to 30 years with mean age 16.43 years. The frequency distribution of subjects with respect to age group, gender and ethnicity is given in Table 1.

**Table 1: Demographic profile of Subjects**

| Demographic profile | n (%) |
|---------------------|-------|
| Age (years)         |       |
| <14                 | 7 (6.1)|
| 14-16               | 70 (60.9)|
| 17-19               | 28 (24.3)|
| >19                 | 10 (8.7)|
| Gender              |       |
| Male                | 33 (28.7)|
| Female              | 82 (71.3)|
| Ethnicity           |       |
| Malay               | 40 (34.8)|
| Chinese             | 61 (53.0)|
| Indian              | 3 (2.6)|
| Iban                | 6 (5.2)|
| Bidayuh             | 4 (3.5)|
| Melanau             | 1 (0.9)|
| Others              | 0 (0.0)|

The present study depicted the incidence of dental caries as 34.8% (Table 2) with the mean 0.61 and standard
deviation 1.19. (Table 3) Among 115 patients, 40 patients (34.8%) had one or more carious tooth/teeth in the oral cavity.

Table 2: Frequency according to presence of cavitated lesions

| Carious teeth | Frequency | Percentage |
|--------------|-----------|------------|
| No           | 75        | 65.2       |
| Yes          | 40        | 34.8       |
| Total        | 115       | 100.0      |

Table 3: Frequency according to the number of cavitated lesions

| No. of caries | Frequency | Percentage | Mean | Standard deviation |
|---------------|-----------|------------|------|--------------------|
| 0             | 75        | 65.2       | 0.61 | 1.19               |
| 1             | 25        | 21.7       |      |                    |
| 2             | 10        | 8.7        |      |                    |
| 3             | 2         | 1.7        |      |                    |
| 6             | 2         | 1.7        |      |                    |
| 7             | 1         | 0.9        |      |                    |
| Total         | 115       | 100.0      |      |                    |

The study showed that the distribution of caries occurrence was highest in age group 14-16 years i.e. 60.0%. However, there was no association between the age group and occurrence of dental caries (Table 4).

Occurrence of dental caries among male and female patients was 30.0% and 70.0% respectively. However, there was no statistically significant association in caries occurrence between gender groups (Table 4).

In a total of 115 orthodontic patients, the occurrence of dental caries was 62.5% in Chinese, 27.5% in Malay, 5.0% in Iban, 2.5% in Bidayuh, 2.5% in Melanau and 0% in Indian patients. However, there was no significant association between the ethnicity and caries occurrence (Table 4).

The recorded number of oral-hygiene instructions between provider and patient was significantly associated with development of cavitated lesions (p=0.017). A decrease was shown for the number of cavitated lesions for patients having more than 2 oral-hygiene discussions (12.5%) versus those with whom oral hygiene was not discussed after the initial oral hygiene instructions (52.5%). (Table 4)

According to the duration of orthodontic treatment, subjects undergoing treatment for less than 25 months duration had 10.0%, 25-35 months had 50.0%, 36-45 months had 30.0%, and more than 45 months had 10.0% occurrence of dental caries. However, there was no association between the duration of orthodontic treatment and caries occurrence (Table 4).

Table 4: Determine associated factors towards dental caries during FOT.

| Independent variable | Carious teeth | | | p-value * |
|----------------------|---------------|-------------|-------------|
|                      | No | % | Yes | % |
| Age (years)          |    |   |    |   |
| <14                  | 5  | 6.7 | 2 | 5.0 | 0.924 |
| 14-16                | 46 | 61.3 | 24 | 60.0 |
| 17-19                | 17 | 22.7 | 11 | 27.5 |
| >19                  | 7  | 9.3 | 3 | 7.5 |
| Gender               |    |   |    |   |
| Male                 | 21 | 28.0 | 12 | 30.0 | 0.821 |
| Female               | 54 | 72.0 | 28 | 70.0 |
| Ethnicity            |    |   |    |   |
| Malay                | 29 | 38.7 | 11 | 27.5 | 0.345 |
| Chinese              | 36 | 48.0 | 25 | 62.5 |
| Indian               | 3  | 4.0 | 0 | 0.0 |
With regards to the quadrant involved, the first quadrant was the most affected (17.4%) whereas the fourth quadrant was the least affected (7.0%). The upper teeth (1st and 2nd quadrants) were more affected than the lower teeth (3rd and 4th quadrants). (Table 5)

**Table 5: Frequency of dental caries according to the quadrant involved**

| Quadrant involved | n (%) |
|-------------------|-------|
| First             | 20 (35.1%) |
| Second            | 17 (29.8%) |
| Third             | 12 (21.1%) |
| Fourth            | 8 (14.0%)  |

The maxillary right first molars (16) were the most affected teeth (8.7%). The least affected teeth were the maxillary right first premolars, mandibular anteriors, mandibular right premolars, mandibular left first premolars and mandibular third molars (0%). (Table 6)

**Table 6: Frequency of dental caries according to type of tooth**

| Type of tooth involved | n (%) |
|------------------------|-------|
| Upper right first molar (16) | 10 (14.3%) |
| Lower left first molar (36) | 7 (10.0%) |

**DISCUSSION**

The present study indicates that carious lesions remains a significant problem during fixed orthodontic...
treatment. The overall incidence found in the present study was 34.8% which falls in the mid-range of the reported figures in the previous literature, which range from 2 to 97% (McGuinness, 1992; Lovrov, Hertrich & Hirschfelder, 2007; Gontijo, Cruz Rde & Brando, 2007). Richter et al., (2011) reported the incidence of new white-spot lesions (WSL) during orthodontic treatment in 72.9% subjects, and the incidence of new cavitated lesions in this population was 2.3%. The highest incidence of WSLs reported in the previous literature (97%) was probably due to the early identification of the presence of WSLs that were not clinically visible as the study used Quantitative Light-induced Fluorescence (QLF) to evaluate the presence of WSLs.

In the present study, we aimed at analysing the effect of age at start of treatment, gender, ethnicity, frequency of oral hygiene instructions and treatment length on the incidence of dental caries.

The results were non-significant in relation to gender while considering the incidence of carious lesions and this finding was similar to the results of Richter et al., (2011). However, some studies reported significant gender differences and indicated that males were having greater risk of developing lesions (Boersma et al., 2005; Chapman et al., 2010).

As for the age group distribution, the present study reveals that there was no significant association between age at the start of treatment and incidence of new carious lesions, consistent with the results of Richter et al. (2011). However, Chapman et al., (2010) showed that younger patients were at higher risk for caries development than the adults.

The results were non-significant in relation to ethnicity while considering the incidence of carious lesions. A study by Chapman et al., (2011) showed that the white ethnic group was at higher risk for caries development during fixed orthodontic treatment.

In the current study, duration of treatment was found to have no significant association with the formation of carious lesions. Richter et al., (2011) found that longer treatment duration was not significantly related to increase cavitated lesions. Lovrov, Hertrich & Hirschfelder (2007) were unable to find an impact of the treatment length on the prevalence of WSLs. However, some studies found increased prevalence of caries with the time period of orthodontic treatment (Tufekci et al., 2011; Chapman et al., 2010).

The number of times that orthodontic care providers offered oral-hygiene instructions was significantly associated with development of new cavitated lesions ($p=0.017$). The frequency of oral-hygiene discussions was associated with lesser number of carious lesions. The importance of repeating the instruction in order to increase the compliance was shown by Ashkenazi et al., (2012) who showed that a significant positive correlation was found between compliance with preventive measures and number and frequency of recall appointments in which patients receive reinforcement. However, Richter et al. (2011) found that the number of oral hygiene conversations increased concurrently with the development of both WSL and cavitated lesions (parameter estimate, 1.88).

With regards to the most affected teeth, it was found in the present study that the maxillary right first molars were the most affected teeth. Similar findings were found by some previous investigators who have reported the most affected teeth to be the maxillary first molars [22]. However, some studies have reported different results, with the most affected teeth reported to be either the maxillary canines or the maxillary lateral incisors (Gorelick, Geiger & Gwinnett, 1982; Tufekci et al., 2011; Ogaard, 1989; Chapman et al., 2010).

This study accounted for only independent variables that were readily available in the patients’ charts. It was by nature limited due to a retrospective design. No information on patients’ socio-economic status, frequency of consulting the dental clinic, prophylactic fluoride therapy, oral hygiene practices and diet habits was available. The relation between new carious lesions and many other variables (e.g. oral hygiene & food habits) were evaluated in other studies. Shrestha et al., (2013) found that large proportion of orthodontic patients consume sweets foodstuff, junk food and snacks in between meals and very few patients practice special oral hygiene measures (interdental brush, fluoride mouthwash).

Unfortunately for this retrospective study, only cavitated carious lesions were recorded. No information on reversible white spot lesions (WSL) was available from the patients’ charts. Previous retrospective studies used pre-treatment and post treatment intraoral photographs
to determine the incidence of labial caries lesions in patients who underwent comprehensive orthodontic treatment with full fixed appliances. However, the photographic method would result in underestimation of reporting the WSL. Some have argued that it is relatively poor for assessing individual lesions longitudinally (Lovrov, Hertrich & Hirschfelder, 2007; Richter et al., 2011). This is due to varying photographic conditions and artefacts between that points: lighting, angulation, and magnification. Intraoral photographs can only provide partial view of the labial surfaces of teeth (Ellwood & O’Mullane, 1994).

Gorelick et al. (1982) compared orthodontically treated patients with untreated controls. Tufekci et al. (2011) compared orthodontic patients in control and treatment group at 6 and 12 months into treatment by control group. Although their study had the benefit of comparisons with a control group, it was cross-sectional in design. What was reported to be the “incidence” of white-spot development was actually the “prevalence” of lesions in the 2 or 3 groups.

The high prevalence and incidence of carious lesions during and after orthodontic treatment with fixed appliances warrants a more detailed investigation of this phenomenon in a prospective randomized controlled clinical trial by using a direct method of assessing early caries lesions with well-documented charting.

**CONCLUSION**

Caries and decalcification continue to be a serious problem as shown by a moderately-high incidence of new cavitated carious lesions (34.8%) in patients treated with fixed orthodontic treatment. Sex, age, ethnicity and treatment length were not associated with lesion development, but a significant association was evidenced with frequency of oral hygiene instructions. The maxillary right first molars were the most affected teeth.

This widespread problem of caries development is an alarming challenge and warrants significant attention from both patients and providers that should result in greatly increased emphasis on oral hygiene reinforcement and effective caries preventive measures. Orthodontists should be aware of the high risk of dental caries and provide intensive oral hygiene instructions and monitoring.

**REFERENCES**

Ashkenazi, M., Bidoosi, M. & Levin, L. (2012). Factors Associated with Reduced Compliance of Children to Dental Preventive Measures. *Odontology*, 100(2), pp 241-248

Balenseifen, J.W.& Madonia, J.V. (1970). Study of dental plaque in orthodontic patients. *Journal of Dental Research*, 49(2), pp 320-324

Bloom, R.H.& Brown, L.R. Jr. (1964). A Study of The Effects of Orthodontic Appliances on The Oral Microbial Flora. *Oral Surgery, Oral Medicine and Oral Pathology*, 17, pp 658-667.

Boersma, J.G., van der Veen, M.H., Lagerweij, M.D., Bokhout, B. & Prahl-Andersen, B.(2005). Caries Prevalence Measured with QLF After Treatment with Fixed Orthodontic Appliances: Influencing Factors. *Caries Research*, 39(1), pp 41-47.

Chang, H.S., Walsh, L.J.& Freer, T.J. (1997). Enamel Demineralization During Orthodontic Treatment. Aetiology and Prevention. *Australian Dental Journal*. 42(5), pp 322-327.

Chapman, J.A., Roberts, W.E., Eckert, G.J., Kula, K.S.& González-Cabezas, C. (2010). Risk Factors for Incidence and Severity of White Spot Lesions During Treatment with Fixed Orthodontic Appliances. *American journal of orthodontics and dentofacial orthopaedics*, 138(2), pp 188-194.

Chatterjee, R.& Kleinberg, I.(1979). Effect Of Orthodontic Band Placement On The Chemical Composition Of Human Incisor Tooth Plaque. *Archives of Oral Biology*, 24(2), pp 97-100

Corbett, J.A., Brown, L.R., Keene, H.J.& Horton, I. M. (1981). Comparison of Streptococcus Mutans Concentrations in Non-Banded and Banded Orthodontic Patients. *Journal of Dental Research*, 60(12), pp1936-1942.

Ellwood, R.P.& O’Mullane, D.M. (1994). Association between dental enamel opacities and dental caries in a north Wales population. *Caries Research*, 28(5), pp 383-387

Featherstone, J.D. (2003). The Caries Balance: Contributing Factors and Early Detection. *Journal of California Dental Association*, 31(2), pp 129-133
Featherstone, J.D., Domejean-Orliaguet, S., Jenson, L., Wolff, M. & Young, D.A. (2007). Caries Risk Assessment in Practice for Age 6 Through Adult. Journal of California Dental Association, 35(10), pp 710-713.

Gontijo, L., Cruz Rde, A. & Brando, P.R. (2007). Dental Enamel Around Fixed Orthodontic Appliances After Fluoride Varnish Application. Brazilian Dental Journal, 18(1), pp 49-53.

Gorelick, L., Geiger, A.M. & Gwinnett, A.J. (1982). Incidence of White Spot Formation After Bonding And Banding. American Journal of Orthodontics, 81(2), pp 93–98.

Lovrov, S., Hertrich, K. & Hirschfelder U. (2007). Enamel Demineralization During Fixed Orthodontic Treatment-Incidence and Correlation to Various Oral-Hygiene Parameters. Journal of Orofacial Orthopedics, 68(5), pp 353-363.

Mattingly, J.A., Sauer, G.J., Yancey, J.M. & Arnold, R.R. (1983). Enhancement Of Streptococcus Mutans Colonization By Direct Bonded Orthodontic Appliances. Journal of Dental Research, 62(12), pp 1209-1211.

McGuinness, N.J. (1992). Prevention in orthodontics-a review. Dental Update, 19(4), pp 168-170.

Mizrahi, E. (1982). Enamel Demineralization Following Orthodontic Treatment. American Journal of Orthodontics, 82(1), pp 62–67.

Ogaard, B. (1989). Prevalence of white spot lesions in 19-year-olds: a study on untreated and orthodontically treated persons 5 years after treatment. American Journal of Orthodontics Orthopedics, 96(5), pp 423-427.

Pinkham, J.R. (1989). Pediatric Dentistry: Infancy Through Adolescence, W. B. Saunders, Philadelphia.

Richter, A.E., Arruda, A.O., Peters, M.C. & Sohn, W. (2011). Incidence of caries lesions among patients treated with comprehensive orthodontics. American Journal of Orthodontics and Dentofacial Orthopedics, 139(5), pp 657-664.

Rosenbloom, R.G. & Tinanoff, N. (1991). Salivary Streptococcus Mutans Levels In Patients Before, During, And After Orthodontic Treatment. American Journal of Orthodontics and Dentofacial Orthopedics, 100(1), pp 35-37.

Scheie, A.A., Arneberg, P. & Krogstad, O. (1984). Effect of Orthodontic Treatment On Prevalence Of Streptococcus Mutans In Plaque And Saliva. Scandinavian Journal of Dental Research, 92(3), pp 211-217.

Shrestha, S., Shrestha, L., Shrestha, N. & Shrestha, R.M. (2013). Effect of Orthodontic Treatment in Occurrence of Dental Caries. Orthodontic Journal of Nepal, 3(1), pp 31-36.

Sukhia, H.R., Ayub, M.A. & Gandhi, D. (2006). Enamel Decalcification in Orthodontic Patients; Prevalence And Oral Distribution - A Cross-Sectional Study. Pakistan Oral Dental Journal, 28(2), pp 193-197.

Tufekci, E., Dixon, J.S., Gunselloy, J.C. & Lindauer, S.J. (2011). Prevalence of White Spot Lesions During Orthodontic Treatment with Fixed Appliances. The Angle Orthodontist, 81(2), pp 206–210.