# Clinical Survey of Cervical Tooth Lesions in First-appointment Patients

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**Objective:** *To investigate the relationship between cervical lesions and patient age, brushing method and bruxism based on a clinical survey of first-appointment patients.*
**Methods:** *Two hundred and nine patients (118 male, 91 female) who had unfilled cervical lesions were examined. Information on patient age, teeth with lesions, classification of the lesions, brushing method and bruxism was obtained. The data were analysed statistically.*
**Results:** *Cervical lesions started to develop in the first premolar teeth in the early twenties and became more prevalent with age. A habit of bruxism was associated with an increase in cervical lesions. Brushing was not directly associated with the development of cervical lesions.*
**Conclusion:** *This study suggests that cervical lesions should be treated at an early stage to prevent further problems.*

**Key words:** *attrition, brushing, bruxism, cervical lesion, dental paste*

Cervical lesions with or without caries are defects that require adhesive restoration. The prevalence of non-carious cervical lesions (NCCLs) has been reported to range from 5% to 85%[1-6], and their prevalence and severity appear to increase with age[6-8]. The mechanisms of NCCL formation remain a major concern among dental practitioners. As early as the beginning of the 20th century, some researchers suggested that NCCLs are caused by brushing teeth; Miller[9] concluded that most NCCLs resulted from mechanical causes, namely brushing. Davis and Winter[10] suggested that abrasion was accelerated by acid-softening or dissolution. Several laboratory and *in situ* studies have supported the hypothesis that NCCLs are increased by a combination of erosion and abrasion[11-15].

A new theory, however, suggesting that occlusion also influences the formation of NCCLs, has recently become the primary focus of attention. Lee and Eakle[16] found that some NCCLs were not caused by abrasion due to brushing, and concluded that they were mainly caused by tensile stress during mastication or bruxism. Grippo[17,18] coined the term 'abfraction', and defined it as the pathological loss of tooth substance caused by biomechanical loading forces resulting in flexure and failure of enamel and dentine. Evidence for abfraction has been derived from finite element studies[3,19,20]. In clinical practice NCCLs present with a range of widths, depths and shapes, and it is difficult to attribute all NCCLs to any one factor. The mechanisms responsible for the formation of NCCLs thus remain unexplained. However, an understanding of their aetiology can help clinicians determine appropriate treatment and management strategies.

This clinical study aimed to survey the formation and development of NCCLs, and to investigate the relationships between NCCLs and age, brushing methods and bruxism. The hypotheses were formulated as follows: *(1)* NCCLs begin to appear in the canine teeth at around 30 years of age, and their incidence increases with age; *(2)* there are differences in the incidence of NCCLs between genders, and depending on handedness; *(3)* there is an association between NCCLs and brushing methods and bruxism.

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**Table 1** Classification of bruxism

| | |
|---|---|
| - | Unrecognised |
| ± | Indistinct |
| + | Attrition of the teeth of the maxilla corresponds with that of the mandible at the time of lateral movement without fricative sound |
| ++ | Attrition of the teeth of the maxilla corresponds with that of the mandible at the time of lateral movement with fricative sound |
| +++ | Subjective symptom or objective symptom was recognised |

**Table 2** Cervical lesions in different age groups

| Age range (years) | Patients (%) | Cervical lesions | Mean ± SD of cervical lesions/patient |
|---|---|---|---|
| 22–29 | 8 (3.8) | 14 | 1.8 ± 1.4* |
| 30–39 | 27 (12.9) | 149 | 5.5 ± 5.2# |
| 40–49 | 31 (14.8) | 142 | 4.6 ± 3.1# |
| 50–59 | 67 (32.1) | 415 | 6.2 ± 4.6# |
| 60–69 | 51 (24.4) | 285 | 5.6 ± 4.1# |
| 70–83 | 25 (12.0) | 128 | 5.1 ± 4.5# |
| Total | 209 | 1133 | 5.4 ± 4.3 |

*Significant ($P < 0.05$) with other groups; #Not significant ($P > 0.05$) within groups.

**Fig 1** Typical angular lesion.

**Fig 2** Typical saucer-shaped lesion.

## Materials and methods

### *Patients*

A clinical survey of NCCLs was conducted over a 2-year period from 2002 to 2004. The subjects included 209 first-appointment patients with an unfilled NCCL, independently of the presence of a filled NCCL, from 3,231 patients who visited the Department of Dentistry, Toranomon Hospital, Japan, from 1 January 2002 to 27 December 2004.

### *Patient characteristics*

The patients gave their informed consent to participate in this study and ethical approval was given by the Toranomon Hospital Ethical Committee. The following characteristics were recorded: patient age, teeth with lesions, classification of the lesions, brushing method, and bruxism. Wisdom teeth were excluded from this survey.

Information on brushing method was obtained by interview and included: daily frequency, manner of holding the toothbrush, method of brushing and the use of dentifrice. Bruxism was classified into five grades, as shown in Table 1.

### *Classification of lesions*

NCCLs were classified into two general types: angular lesions, defined as those formed by two planes (Fig 1), often referred to as wedge-shaped or V-shaped defects; and saucer-shaped lesions, defined as other concave defects (Fig 2).

### *Statistical analysis*

Examinations were carried out by the practitioner in charge of each patient. The data obtained were analysed statistically using Kruskal-Wallis, Mann-Whitney and Wilcoxon signed-rank tests (IBM SPSS Statistics 19) at the 5% level of significance.

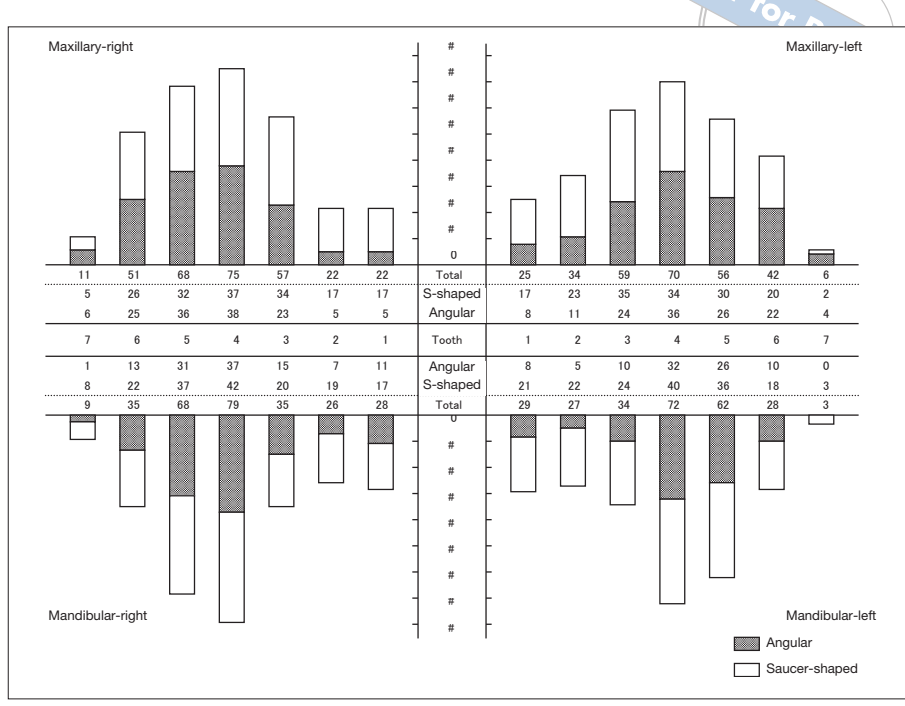


**Fig 3** Numbers of cervical lesions by tooth position.

## Results

The total number of patients participating in the survey was 209. Their mean age ± standard deviation (SD) was 54.3 ± 13.0 years. There were 118 males (23 to 82 years old, mean age 54.7 ± 12.7 years), and 91 females (22 to 83 years old, mean age 53.9 ± 13.3 years).

There was a total of 1,133 lesions, including 475 angular and 658 saucer-shaped lesions (Fig 3).

According to age, NCCLs initially developed in the early twenties. Their incidence increased rapidly from the twenties to the thirties, rose to a peak in the fifties, and then decreased gradually (Table 2). There was a significant difference between the mean numbers of lesions in the twenties and thirties ($P < 0.05$), but there were no significant differences among the five groups older than the twenties ($P > 0.05$).

The mean number of NCCLs per patient in males was 5.7 ± 4.6 and females 5.1 ± 4.1. There was no significant difference between the genders ($P > 0.05$).

The relationships between NCCLs and brushing are shown in Tables 3 to 6. Table 3 shows the relationship between number of NCCLs and daily brushing frequency. The mean number of NCCLs tended to increase with more frequent brushing, but the differences were not significant ($P > 0.05$). Table 4 shows the relationship between number of NCCLs and the hand used to hold the toothbrush. There were no significant differences between right hand and left hand in any group ($P > 0.05$). Table 5 shows the relationship between the number of NCCLs and brushing method. No significant differences were found among the four brushing methods ($P > 0.05$). More than 90% of patients used dentifrice (Table 6). There was no difference between the group that used dentifrice and the group that did not ($P > 0.05$).

Regarding the severity of bruxism, 81 patients were classified as '–' and 128 patients were classified as either '±', '+', '++' or '+++'. The number of NCCLs was significantly higher in patients with bruxism than in those without bruxism ($P < 0.05$, Table 7). In the bruxism '–' group, 33 patients had only angular-shaped lesions, while another 33 had only saucer-shaped lesions. There was no significant difference between the two groups in terms of number of lesions ($P > 0.05$). Within the four groups of patients with varying degrees of bruxism, 45 had only angular-shaped lesions, while 50 had only saucer-shaped lesions. There was no significant difference between the two groups in terms of number of lesions ($P > 0.05$).

## Discussion

The results of this study show that NCCLs could occur in all teeth, especially premolars and canines. These lesions were classified as either angular or saucer-shaped. Angular lesions occur when cervical loss precedes gingival loss, while saucer-shaped lesions occur when cervical

**Table 3** Cervical lesions in relation to brushing frequency

| Brushing times/day | Patients (%) | Cervical lesions | Mean ± SD of cervical lesions/patient |
|---|---|---|---|
| 1 | 35 (16.7) | 148 | 4.2 ± 2.8[#] |
| 2 | 109 (52.2) | 590 | 5.4 ± 4.4[#] |
| 3 or more | 65 (31.1) | 395 | 6.1 ± 4.8[#] |

[#]Not significant ($P > 0.05$) with other proups.

**Table 4** Cervical lesions in relation to handedness

| Hand holding brush | Patients (%) | Cervical lesions | | Mean ± SD of cervical lesions/patient | |
|---|---|---|---|---|---|
| | | Right | Left | Right | Left |
| Right | 187 (89.5) | 511 | 480 | 2.7 ± 2.3 | 2.6 ± 2.4 |
| Right and left | 8 (3.8) | 25 | 24 | 3.1 ± 2.8 | 3.0 ± 3.2 |
| Left | 14 (6.7) | 50 | 43 | 3.6 ± 2.5 | 3.1 ± 3.5 |

Not significant ($P > 0.05$) between right and left in each group.

**Table 5** Cervical lesions in relation to brushing methods

| Brushing method | Patients (%) | Cervical lesions | Mean ± SD of cervical lesions/patient |
|---|---|---|---|
| Vertically and horizontally | 66 (31.6) | 374 | 5.7 ± 4.8 |
| Vertically | 56 (26.8) | 317 | 5.7 ± 4.2 |
| Horizontally | 80 (38.3) | 407 | 5.1 ± 4.2 |
| Subtotal | 202 | 1,098 | 5.4 ± 4.4 |
| Electric brush | 7 (3.3) | 35 | 5.0 ± 2.4 |

Not significant ($P > 0.05$)

**Table 6** Cervical lesions in relation to use of dentifrice

| Use of dentifrice | Patients (%) | Cervical lesions | Mean ± SD of cervical lesions/patient |
|---|---|---|---|
| With | 189 (90.4) | 1,031 | 5.5 ± 4.5 |
| Without | 20 (9.6) | 102 | 5.1 ± 3.2 |

Not significant ($P > 0.05$).

**Table 7** Cervical lesions in relation to bruxism

| Severity of bruxism | Patients (%) | Cervical lesions | Mean ± SD of cervical lesions/patient | |
|---|---|---|---|---|
| – | 81 (38.8) | 375 | 4.6 ± 3.7* | |
| ± | 43 (20.6) | 303 | 7.0 ± 5.6 | 5.9 ± 4.7* |
| + | 70 (33.5) | 386 | 5.5 ± 3.9 | |
| ++ | 4 (1.9) | 41 | 10.3 ± 7.0 | |
| +++ | 11 (5.3) | 28 | 2.5 ± 1.0 | |

*Significant ($P < 0.05$).

loss follows gingival loss. This suggests that younger patients should have more angular-shaped than saucer-shaped lesions. In this study, no relationship between the presence of bruxism and the shape of lesions was identified. However, further studies with larger sample sizes are needed to clarify the significance of lesion shape.

Analysis of the relationship between NCCLs and patient age showed that the mean number of NCCLs increased from the twenties to the thirties. This may be attributed to increased occlusal stress, such as that caused by bruxism, causing the development of more lesions, especially in the over-thirties group. In contrast, the mean number of lesions tended to decrease from the thirties to the forties and in the over-sixties group. This could be because existing lesions had already been restored with resin composite or glass ionomer cement or because of tooth loss. The Report on the Survey of Dental Diseases 2005 by the Ministry of Health and Welfare Japan[21] identified a growing tendency for patients to lose their teeth beyond 60 years of age.

A total of 14 NCCLs were observed in eight patients in their twenties. Six of the 14 lesions developed in the first premolars in the maxilla or mandible (Fig 4), and these were the largest of the teeth. Interestingly, prior to this survey, the present authors assumed that NCCLs initially developed in the canines, because such lesions in the canines are frequently identified and restored. However, the results of this study suggest that NCCLs initially form in the first premolars, a fact that has not been reported previously, thus partially refuting hypothesis 1.

Miller[9] and Hirschfeld[22-24] concluded that NCCLs are mainly caused by mechanical abrasion combined with brushing. A large cross-sectional study of 818 subjects showed an increase in the prevalence of NCCLs in patients (12% of the total) who brushed twice daily, compared with those who brushed less frequently.[1] In the current survey, however, no significant relationship was found between the mean number of NCCLs and the frequency of brushing, although there was a tendency towards more lesions in patients who brushed more frequently. Only unfilled lesions were considered in this survey; if both unfilled and filled lesions were recorded, the results might have been different.

Miura[25,26] reported more NCCLs on the left side among patients who handled their toothbrush using the right hand, and more NCCLs on the right side in patients who brushed with their left hand. If the force generated during brushing is important, then more lesions might be expected to occur on the side of the mouth opposite the hand holding the brush[27,28]. No such relationship between the right or left hands and the location of NCCLs was identified in the current study. This might also have been because only unfilled NCCLs were considered and the more severe lesions had already been restored in some patients. However, these results partially refute hypothesis 2.

**Fig 4** Typical early-stage cervical lesion in a first premolar in the maxilla.

Shimura[29] reported that more NCCLs were found in patients who used hard toothbrushes horizontally, based on statistical analysis of data from 1,320 patients. Early clinical studies suggested that toothbrush handling influenced the wear of teeth, with horizontal brushing causing two to three times as much wear as vertical brushing[30]. The current study, however, found no significant differences in frequencies of NCCLs among the three brushing methods: horizontal, vertical or both horizontal and vertical. This suggests that horizontal brushing is not necessarily a predominant factor affecting the prevalence and development of NCCLs. Furthermore, seven patients who used electric brushes had a mean of 5.0 NCCLs, which was not significantly different from the numbers in patients using manual brushing methods. The small number of patients who used electric brushes reflects the fact that these are not yet popular in Japan.

Miura[25,26] generated cervical lesions on extracted teeth using a toothbrush and dentifrice. He concluded that mechanical abrasion caused by brushing with a paste was a major factor in the development of NCCLs, and that demineralisation by acid and the development of caries were only partially responsible for the development of NCCLs. Over 90% of the patients in the current survey used a dentifrice. Although the 'dentifrice' group had slightly more NCCLs than the 'without dentifrice' group, the difference was not significant. The role of dentifrices in the prevalence and development of NCCLs thus remains unclear, but there is little evidence to suggest that NCCLs are solely caused by abrasion[31].

**Fig 5** Newly developed cervical lesion at the gingival side of a resin composite restoration in a cervical cavity in a first premolar in the mandible.

NCCLs do not always occur exclusively on surfaces exposed to obvious physical factors, such as the abrasive action of brushing. Indeed, the present authors observed some lesions on the palatal and lingual surfaces of the teeth, where friction due to brushing was unlikely because of their inaccessibility. Sognnaes et al[32] found that neither toothbrush nor toothpick friction alone could explain these cases.

Lee and Eakle[16] explained that mastication and bruxism generate lateral forces between the teeth in the maxilla and mandible, and that lateral forces create tension and compression in the cervical regions of the tooth. The tensile stress disrupts the chemical bonds between the enamel rods, gradually breaking the enamel and dentine in the cervical regions, resulting in an NCCL. This may be referred to as the 'tensile stress-induced cervical erosion theory'. Furthermore, they suggested that other factors, such as mechanical abrasion, might play roles in lesion development once cervical loss is initiated. Some researchers therefore attribute NCCL to abfraction.[17] Abfraction describes a theoretical process whereby occlusal forces create stresses in the enamel and dentine along the cervical area and thus predispose it to erosion and abrasion.

The present authors investigated the relationship between bruxism and the occurrence of NCCLs; more lesions were found in patients with a habit of bruxism, or in those suspected of having a habit of bruxism. Otsuki et al[33] suggested that NCCLs might develop as a result of the reciprocal action of both abrasion due to brushing and occlusion, and that the main cause might vary between individuals. Grippo et al[34] described how the mechanisms of stress, corrosion and friction appeared to be critical factors in the aetiology and progression of tooth-surface lesions. The results of the current study confirmed that bruxism increases the incidence of NCCLs.

NCCLs often appear to develop at the gingival side, even after the primary lesion has been filled (Fig 5). This implies that NCCLs which are not restored at an early stage are likely to develop into more severe lesions. NCCLs should thus be restored at an early stage to prevent further problems.

Otsuki et al[33] prepared and restored cervical lesions in extracted teeth using resin composite and then applied periodic loading parallel to the tooth axis. Cracks resembling cervical lesions developed at the gingival margin of the resin composite restoration. This suggested that tensile stress was concentrated in the cervical region. Francisconi et al[35] concluded that occlusal loading leads to a significant increase in gap formation at the margins of cervical resin-based composite restorations. Thus, the occlusal contact to the antagonistic tooth and the characteristics of the restorative materials should be taken into consideration when restoring cervical lesions. Increased tensile stress in the cervical region is especially likely to occur in patients with a habit of bruxism. Resin composites with a lower elastic modulus should be used to reduce the risks of marginal fractures or loss of the restorative material.

The results of this clinical survey suggest that NCCLs initially develop in the first premolars in the early twenties, and that their incidence increases rapidly from the twenties to the thirties. A habit of bruxism was associated with the occurrence of NCCLs ($P < 0.05$), while other factors examined were not directly associated with lesion development ($P > 0.05$). These results would be likely to differ with regions or countries. Further studies are needed to determine the aetiology of NCCLs. Thus regarding the initial hypotheses, only bruxism was identified as a factor promoting the development of NCCLs.

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