Abstract

Purpose: This study was conducted to investigate the incidence and predictors of hypercementosis in mandibular third molars using cone beam computed tomography.

Methods: Using a retrospective approach, 1,160 cone beam computed tomography image sets were analyzed. Two oral radiologists independently evaluated the image sets based on four severity grades: 0, no hypercementosis around the root; 1, hypercementosis surrounding less than half of the root surface; 2, hypercementosis surrounding more than half of the root surface; and 3, hypercementosis surrounding the entire root surface. Hypercementosis was defined as a dark or light layer. Statistical analyses of relationships between hypercementosis incidence and possible predictors (e.g., age, sex, impaction, and occlusion) were performed using chi-square test or Fisher’s exact test; logistic regression was used for multivariate analysis.

Results: The severity of hypercementosis increased with age, and the incidences were as follows: ≤19 years, 0%; 20-24 years, 14.1%; 25-29 years, 57.7%; 30-39 years, 83.0%; 40-49 years, 92.7%; 50-59 years, 93.4%; and ≥60 years, 96.8%.

Conclusion: The observed incidences of hypercementosis were relatively higher than in previous studies, and the incidence was significantly lower for occluded teeth than for non-occluded teeth.

Keywords: cone beam computed tomography, hypercementosis, impaction, mandibular third molar, occlusion

Introduction

Mandibular third molars (M3s) are teeth that erupt during growth into adulthood, but their rates of eruption are typically slower than those of other teeth. M3s tend to be affected by various oral diseases due to their position and surrounding environment. The rate of M3 impaction reportedly varies among ethnicities, but is generally presumed to be approximately 25% (range, 3-57%) [1-4]. The existence of both impacted and normally erupted M3s causes diseases such as cellulitis involving gingival swelling and pain, as well as pericoronitis, malocclusion, and osteomyelitis [5,6]. In addition, bone absorption and destruction of neighboring teeth may occur due to poor oral hygiene and formation of bacterial foci [7].

Most M3s are extracted at an early age, but these surgical procedures are risky and may be accompanied by complications [8-10]. Notably, most complications (e.g., postsurgical infection, inferior alveolar nerve [IAN] paralysis, lingual nerve injury, mandibular fracture, and trismus) occur postoperatively, rather than intraoperatively [11-13]. Progression of postoperative infections to recalcitrant osteomyelitis is a serious problem, although this is relatively infrequent [14,15]. IAN paralysis is a very serious complication; although it is often temporary, it may become permanent.

Diagnosis and preoperative inspection are important for prevention or mitigation of these complications. Subsequently, treatment plans are established by oral surgeons [16]. Two-dimensional panoramic X-ray radiographs are conventionally used to assess the relationship between the M3 and inferior alveolar canal (IAC). Close relationships have been demonstrated among interruption of the white line, root darkening, IAC or root narrowing, root deflection, root darkening and splitting, root deflection, and/or IAC diversion.

In recent years, the use of cone beam computed tomography (CBCT) has demonstrated the three-dimensional details of anatomical structures associated with M3s and the surrounding tissue [17,18]. CBCT images are used to determine the state of the M3 (e.g., impaction or eruption, and angles relative to the occlusal and buccolingual planes), tooth morphology (e.g., root number, relationship between tooth and mandibular canal or blood vessels branching from the mandibular canal), root apex position, and lingual cortical bone thickness [19]. This information can be used to determine the treatment plan, including whole extraction or partial removal (i.e., coronectomy) [20,21].

It appears that no previous report has described the tooth root contours of impacted M3s. The contours of impacted M3s involve cementum hyperplasia or hypercementosis. Teeth with hypercementosis reportedly exhibit less mobility during orthodontic treatment, and are difficult to manipulate during endodontic treatment [22,23]. Accordingly, M3s with hypercementosis may be difficult to extract because of ankyloses or strong adhesion to bone structure. In this retrospective study, CBCT was used to analyze the incidence of M3 hypercementosis, with the aim of clarifying the relationships between hypercementosis incidence and age, sex, impaction status, and occlusion status.

Materials and Methods

Study design

This retrospective study was approved by the ethics committee of Tokyo Medical and Dental University (approval no. D2018-032). All study procedures were performed in accordance with the relevant guidelines and regulations. All image data sets were analyzed retrospectively which were stored in the image servers under the usable status for academic studies informed to patients.

Patients and CBCT images

In total, 1,181 CBCT image sets that included M3s were collected from 957 consecutive patients between January 2018 and December 2018 in the Dental Hospital of Tokyo Medical and Dental University, then analyzed retrospectively. Twenty-one patients who had cysts with a thickness of ≥3 mm around the M3 crown (18 patients) or hard motion artifacts (three patients) were excluded. Finally, 1,160 image sets were evaluated in this study (512 male patients and 648 female patients; mean age, 36.5 ± 12.8 years [range, 16-86 years]). The CBCT examinations were performed for several reasons, in accordance with orders from dentists in clinical outpatient departments. Most were performed for preoperative inspections of M3s prior to extraction; diagnoses for other lesions were also included (e.g., dental caries, periodontitis, pericoronitis, and pulpitis).

CBCT image acquisition was performed using a 3DX Multi Image CT FPD8 (J. Morita Mfg. Corp., Kyoto, Japan) with the following parameters: field of view, 4 × 4 cm or 6 × 6 cm; minimum voxel size, 80 × 80 × 80 µm or 120 × 120 × 120 µm; tube voltage, 90 kV; tube current, 5-8 mA; and acquisition time, 9.0 s or 17.5 s. To reduce image noise and save data

Original article

Incidence of hypercementosis in mandibular third molars determined using cone beam computed tomography

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size, each image set was reformatted and stored as axial images with slice thicknesses of 160 µm or 240 µm, depending on the field of view size.

Image analysis
For image analysis, two 20-inch high-resolution liquid-crystal display monitors (RadiForce RX240; Eizoonanoo Corp., Tokyo, Japan) were used with the RapideyeCore viewing software (Canon Medical Systems Corp., Otawara, Japan) on a computer running Windows 10 (Microsoft Corp., Redmond, WA, USA). This software was used for multi-planar reconstruction to identify three planes orthogonal to each other.

Two oral radiologists (with 33 years and 7 years of experience respectively) independently evaluated the 1,160 image sets using the monitors and software described above, using DICOM data archived on a storage server. Hypercementosis was identified as a layer with distinct density, which exhibited voxel values that differed from root dentine (Fig. 1). They classified the image sets according to the following four grades of hypercementosis severity: 0, no hypercementosis around the root; 1, hypercementosis surrounding less than half of the root surface; 2, hypercementosis surrounding more than half of the root surface; 3, hypercementosis surrounding the entire root surface.

The evaluation was performed in a blinded manner and random order, without access to patient and clinical data. Axial image sets limited to the longitudinal axes of teeth were primarily used during classification; the observers were also able to use coronal and sagittal image sets. Furthermore, the observers were permitted to re-slice images parallel or vertical to the longitudinal axes of roots, and to change the brightness and contrast values. Inconsistencies were resolved by collaborative review and consensus agreement. To analyze interobserver variability, the observer with 33 years of experience re-evaluated 300 randomly selected patients at least 1 month after the initial evaluation.

Impaction and occlusion statuses
Impaction status was categorized as complete or “other” (i.e. eruption or partial impaction). Complete impaction was defined as crown coverage by a radiopaque line in the bone capsule and coverage of all roots with bone in all images of a specific set. In this context, the entire impacted tooth was presumably buried by bony structure. When a crown was not completely surrounded by bone, it was easily infected.

Occlusion was determined according to whether at least one point contacted a maxillary tooth in all images of a specific set. Teeth with occlusion were considered functional teeth, which were continuously stimulated by occlusion that extended from the crown to the root.

Statistical analysis
For analysis of the relationship between the incidence of hypercementosis and age, patients were divided into seven subgroups: ≤19 years, 20-24 years, 25-29 years, 30-39 years, 40-49 years, 50-59 years, and ≥60 years. Statistical analyses were performed using SPSS statistical software, version 17.0 (SPSS Inc., Chicago, IL, USA). Interobserver and intraobserver variability were calculated by κ analysis: κ ≤0.2, fair; 0.2 < κ ≤0.4, moderate; 0.4 < κ ≤0.6, 0.6 < κ ≤0.8, good; and 0.8 < κ ≤1, excellent. To analyze the incidence of hypercementosis, grade 0 was considered “hypercementosis negative,” while grades 1, 2, and 3 were considered “hypercementosis positive.” Chi-squared test was used to investigate the relationship between age and hypercementosis incidence, while Fisher’s exact test was used to investigate the relationships of hypercementosis incidence with other potential predictors. Significant predictors were identified by univariate analysis, then confirmed by multivariate logistic regression analysis.

Results
The M3 roots of 1,160 patients were evaluated in this study. The κ values of interobserver and intraobserver agreement were 0.72 and 0.78, respectively, indicating good agreement.

Table 1 and Fig. 2 show hypercementosis severity in M3s according to age group. In the ≤19 years group, all patients exhibited grade 0 hypercementosis in M3 roots. Hypercementosis was observed only in patients ≥20 years of age; the incidence increased with age. Hypercementosis severity also increased with age; in patients ≥30 years of age, grade 3 hypercementosis was increasingly common. Table 2 shows the incidences of hypercementosis stratified according to age and sex. The incidence increased sharply in patients ≥20 years of age and reached a plateau in patients ≥40 years of age (Fig. 3). Furthermore, hypercementosis was present in >90% of patients aged ≥40 years. In each age group, the incidence was higher in male patients than in female patients.

Table 3 shows the incidence of hypercementosis stratified according to sex, site, occlusion status, and impaction status. Hypercementosis was more common in male patients, in left-sided sites, in non-occluded M3s,
Hypercementosis grade stratified according to age group. In the ≤19 years group, no hypercementosis was observed. The incidence of grade 3 hypercementosis increased with age. The incidence increased considerably in the 25-29 and 30-39 years groups.

Other significant predictors included increasing patient age. Hypercementosis became significantly more frequent with age. Between the incidence of hypercementosis and various potential predictors, multivariate logistic regression showed that age, sex, and occlusion status were significantly associated with the incidence of hypercementosis.

**Discussion**

In this study, hypercementosis was frequently present in M3s. Hypercementosis is a hereditary condition associated with aging and factors such as inflammation, developmental disorders, and systematic conditions (e.g., thyroid disease, rheumatic fever, arthritis, acromegaly, and Paget’s disease) [24,25]. On the basis of radiographic analyses, Weinberger described two distinct types of hypercementosis. The most common type cannot be radiographically differentiated from original cementum; this type has been associated with hypertrophic arthritis, traumatic occlusion, Paget’s disease, and acromegaly. The other type more often exhibits radiolucent cementum and has been identified in patients with a history of rheumatic fever [26]. The diagnostic criteria for hypercementosis in this study were the presence of a layer that differed from the original tooth root in X-ray plates. In this study, patients’ medical histories were not investigated, but it was considered likely that most patients did not have a history of rheumatic fever. Therefore, the change in cementum layer radiopacity was presumably caused by another factor. Because the formation of hypercementosis was visible from an early age and proceeded rapidly, low X-ray radiopacity might have originated from differences in formation speed.

Some authors have classified hypercementosis according to morpho-

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**Table 2** Incidence of hypercementosis according to age group and sex.

| Age     | Total | Male | Female |
|---------|-------|------|--------|
| < 19    | 37    | 37   | 0      |
| 20-24   | 163   | 140  | 23     |
| 25-29   | 234   | 198  | 36     |
| 30-39   | 311   | 285  | 26     |
| 40-49   | 232   | 209  | 23     |
| 50-59   | 121   | 107  | 14     |
| 60+     | 62    | 56   | 6      |

**Table 3** Incidence of hypercementosis according to sex, site, occlusion status, and impaction status.

| Site | Total | Male | Female |
|------|-------|------|--------|
| Right| 572   | 36.2 | 383    |
| Left | 588   | 36.8 | 421    |

**Table 4** Factors associated with hypercementosis incidence.

| Category | Univariate analysis | Multivariate analysis |
|----------|---------------------|-----------------------|
| Sex      | 0.029               | 0.021                 |
| Site     | 0.098               |                       |
| * Occlusion | * P < 0.001          | * P < 0.001          |
| Impaction | 0.186               |                       |

*Significantly different (*P < 0.05*)
In addition, the radiation dose in CBCT examinations was optimized for growth in the buccolingual direction. In grade 1 hypercementosis, cementum using conventional images, it is difficult to detect cementum formation and which might have improved the detection of subtle changes in teeth. When panoramic radiographs were used. In the present study, CBCT was used, numbers of patients, conventional images (e.g. intraoral radiographs or panoramic radiographs). Close relationships were previously described among the following radiographic markers [14]: interruption of the white line of the IAC; root darkening; IAC or root narrowing; root darkening and splitting; root deflection; and IAC diversion. Using two-dimensional radiographs, these close relationships were assumed, but could not be demonstrated three-dimensionally without using CBCT images. Korkmaz et al. [38] reported that CBCT images could not reduce the risk of permanent IAN injury, although they were able to diminish the prevalence of temporary IAN injury. However, the study by Korkmaz et al. did not investigate hypercementosis. Because of stiff adhesion with surrounding bone, hypercementosis might be a risk factor for IAN injury or bone fracture.

Perioperative complications of M3 extraction include root fracture, bleeding, tuberosity fracture, soft tissue injury, and adjacent root damage. Postoperative complications include swelling, pain, trismus, dry socket, alveolitis, infection, and lingual nerve/IAN paresthesia [7-9]. Blondeau et al. [8] proposed that surgical removal of impacted M3s should be performed before the age of 24 years. Furthermore, Chuang et al. [9] concluded that older age (>25 years) was associated with a higher rate of complications during M3 extraction. Factors proposed to trigger these complications included greater bone density, surgical difficulty, complete root formation, and reduced healing capacity [3,4]; however, hypercementosis of the root was not considered. Because the incidence of hypercementosis increased in patients aged ≥25 years (as indicated in this study), the increased complications after M3 extraction might be related to hypercementosis adherence. This study had some limitations. First, most images were taken preoperatively, which might have led to a bias whereby most teeth were impacted and less likely to be occluded. Second, this study did not investigate the relationships of hypercementosis with difficulty indicators (e.g. operation time or surgeon’s impression). Finally, most patients were Japanese, so this study might have been subject to ethnic bias.

In conclusion, M3 hypercementosis was observed in patients ≥20 years of age, and its incidence increased with age. The incidence was >50% in patients ≥25 years of age, whereas it was ≥90% in patients ≥40 years of age. Furthermore, the incidence was significantly lower in occluded teeth and less likely to be hypercementosis. Hypercementosis is presumed to involve strong adhesion with surrounding bone, hypercementosis might be a risk factor for IAN injury or bone fracture.

Students were subjects aged ≥60 years, and the study was approved by the Human Ethics Committee. All patients provided written informed consent before undergoing the examination. The results of the present study imply that the incidence of hypercementosis is not consistent among age groups, and it might have been useful to measure cementum thickness. Although measurements of this cementum thickness were not performed, it was inconsistent and variable; moreover, it was affected by root type, root position (medial, buccal, lingual, or distal), and periodontal disease status [36,37]. Furthermore, cementum thickness appeared to increase with age.

There are many risks involved in M3 extraction. IAN damage, cortical bone fracture, postoperative infection and inflammation, and lingual nerve damage are commonly regarded as risks of surgical manipulation. CBCT has been used to prevent and mitigate bone fracture [12-13] and IAN damage. It is able to clearly delineate the M3, IAC, and mandibular cortical bone in a three-dimensional manner. Surgeons can use the information regarding the morphological shape of an M3, combined with the three-dimensional relationship between the M3 and its neighboring anatomical structures [16-19], to create a surgical plan that allows effective extraction or coronectomy [20]. Notably, some studies have shown that CBCT did not reduce the risk of IAN damage [38,39].

According to guidelines established by the European Commission on Radiation Protection, the use of CBCT is justified when it will provide new information. Thus, CBCT use is only appropriate when high intraoperative and postoperative risk is suspected by conventional images (i.e. intraoral radiographs and panoramic radiographs). Close relationships were previously described among the following radiographic markers [14]: interruption of the white line of the IAC; root darkening; IAC or root narrowing; root darkening and splitting; root deflection; and IAC diversion. Using two-dimensional radiographs, these close relationships were assumed, but could not be demonstrated three-dimensionally without using CBCT images. Korkmaz et al. [38] reported that CBCT images could not reduce the risk of permanent IAN injury, although they were able to diminish the prevalence of temporary IAN injury. However, the study by Korkmaz et al. did not investigate hypercementosis. Because of stiff adhesion with surrounding bone, hypercementosis might be a risk factor for IAN injury or bone fracture.
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