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Morphological Variations of the Mandibular Premolars

Tooth Morphology and Identification - A Macro Analysis

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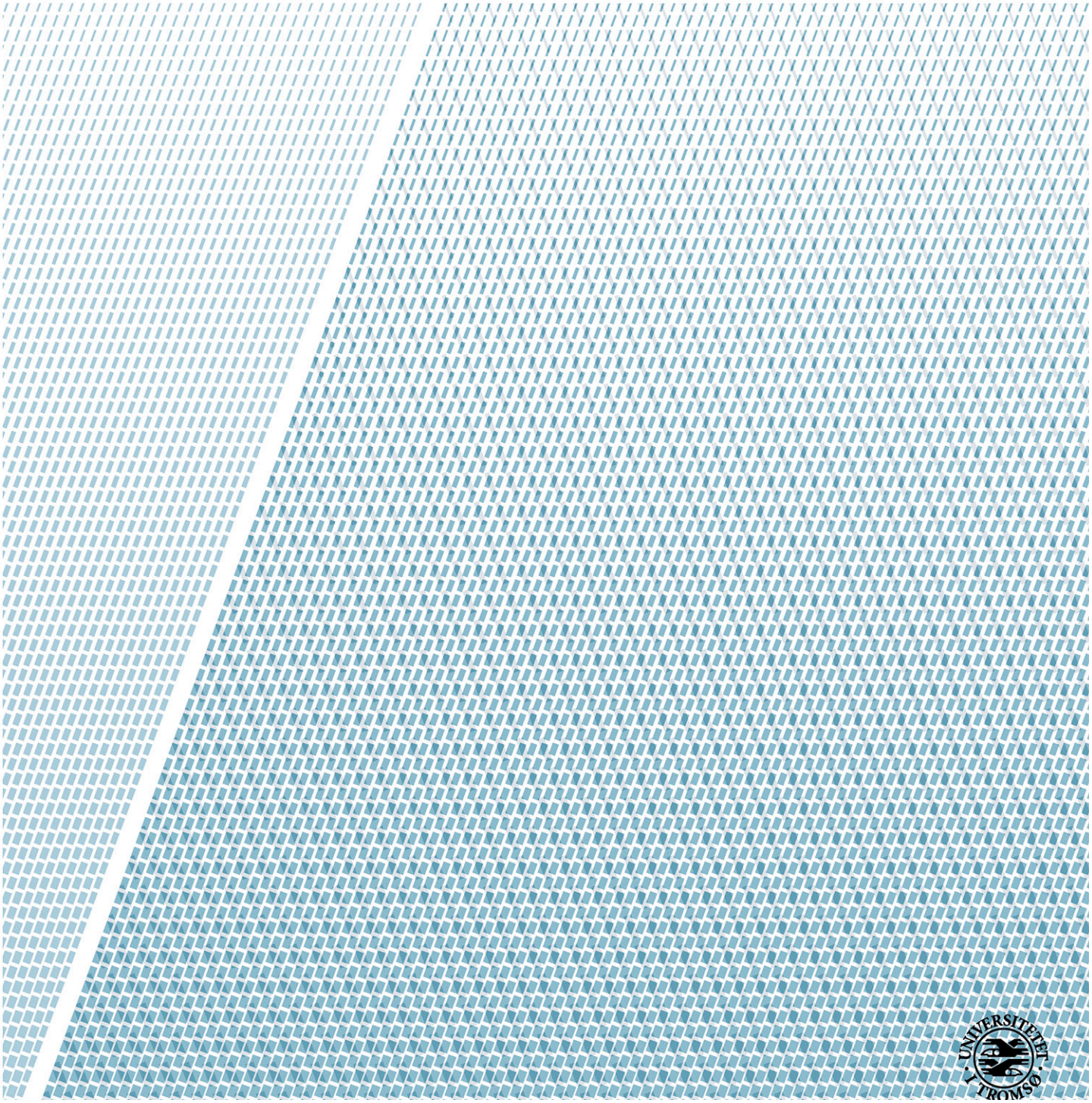

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Abstract

Background

In the context of teaching tooth morphology to dentist students, which is based on the anatomical and morphological hallmarks described in the literature, some of the teeth in the permanent dentition have shown to be harder to characterize than others. The aim of this project was to specifically focus on the premolars of the lower jaw. By studying a collection of extracted teeth and dental casts, we wanted to explore why the task of differentiating and deciding premolars remain troublesome, and look for novel morphological features on the lower jaw premolars. The knowledge gained here may therefore be useful in the teaching of dental morphology in general, or even interesting in the context of anthropological and developmental biological studies.

Material and methods

A total of 216 extracted mandibular premolars from University of Oslo and University of Tromsø – The Arctic University of Norway were selected and studied for quality, and then separated into three groups by four evaluators as: "typical 1st premolars", "typical 2nd premolars" and "atypical premolars". The teeth were then organized in subgroups and photographed from different dental aspects. In addition, 30 dental casts contributed from the Public Dental Service Competence Center of Northern Norway were measured and photographed.

Studying and analyzing the extracted teeth and dental casts led to a proposal of eleven different hypotheses. These hypotheses were then used one at a time to categorize the "atypical premolars" as a 1st or a 2nd premolar, by three independent evaluators. Significant agreements among the evaluators were then used as a measurement for "strong", "medium" or "weak" morphological features.

Results and conclusion

Out of the eleven proposed hypotheses, we report four novel features from this study. The first feature states that when observed from an approximal aspect "the marginal ridge line ends centrally on the 2nd premolars, but it continues further towards the lingual aspect on the 1st premolars". The second feature indicates that when observed from an occlusal angle, "the

pits making up the central fissure will align on a centrally straight line placed (mesio-distal axis) in the 2nd premolars, but not in the 1st premolars". The third feature describes a significant difference in the width/height-ratio of the two lower premolars when observed from a facial aspect. The fourth feature demonstrates that the observable facial aspect, when observed from an occlusal aspect, differs between the premolars.

Introduction

Histologically the tooth consists of four different tissues; enamel, dentin, pulp and cement. Morphologically the tooth consists of a crown and a root. The part of the tooth having the enamel as the upper layer is called the anatomical crown, and the part having the cement as the covering layer is called the anatomical root (1) (Figure 1).

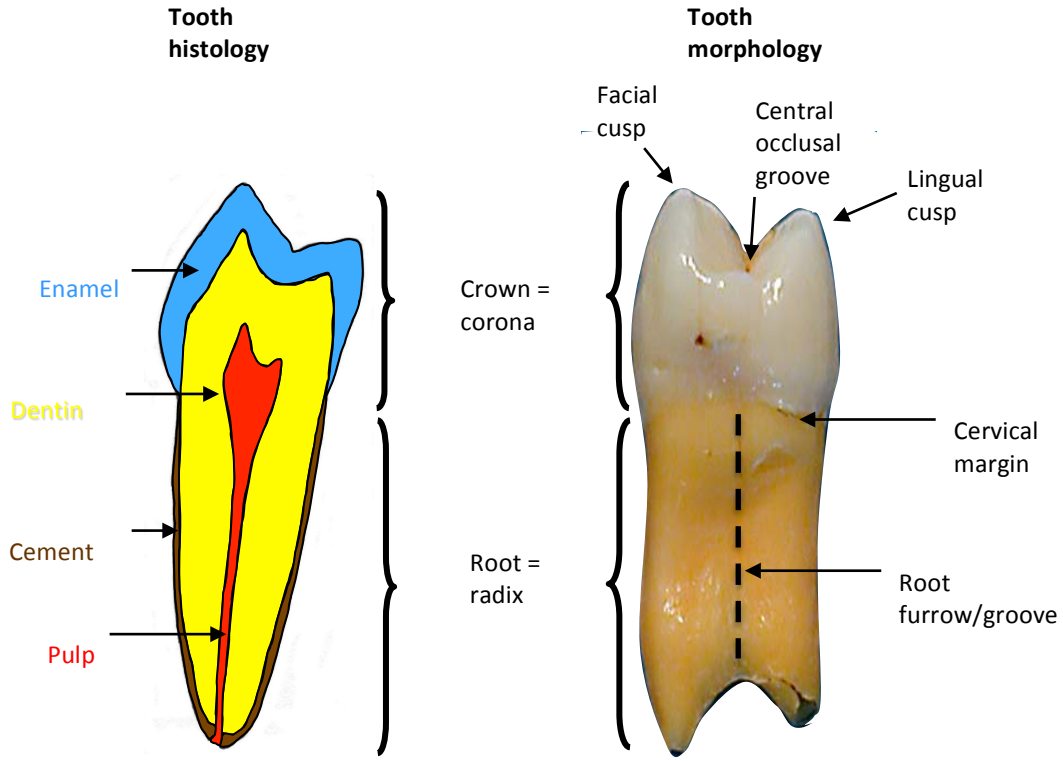


Figure 1: Anatomical and morphological overview of a tooth, Courtesy of Steinar Risnes.

The oral cavity is divided into four quadrants, two in each jaw. Each quadrant consists of 2 incisors, 1 canine, 2 premolars and 3 molars, and can therefore have a maximum of 8 permanent teeth (2), which is shown in figure 2. The total number of teeth in the oral cavity can vary from 28 to 32, which depends on the presence of the 3rd molars (wisdom teeth).

The anatomy of the teeth differs between each tooth. Also, the detailed morphology may vary greatly between individuals and populations (3). However, the teeth display anatomical and morphological aspects (number of cusps, roots and other geometrical features) that can be

used to separate them not only into their specific groups (incisors, canines, premolars and molars), but also to separate one specific tooth from an another (i.e. upper right first premolar from lower first right premolar).

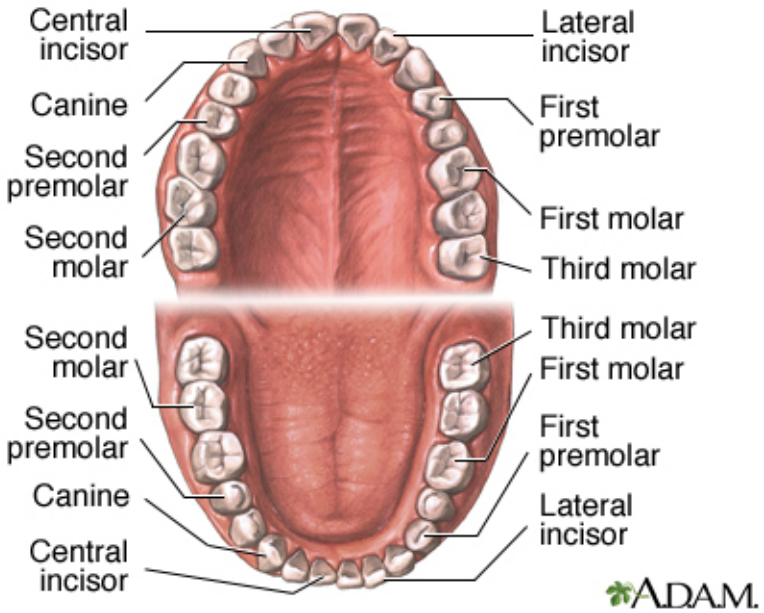


Figure 2: An illustration of the permanent dentition (4).

Although the specific field of dental anatomy is relatively small, the study of the molecular factors that drives the variations through tooth development has been important in our modern understanding of morphological patterning. The knowledge of dental morphology is not only relevant for the professions related to oral health, but have also proven useful in the fields of anthropological and developmental biology (5).

However, a detailed understanding of the tooth's anatomy remains especially important for the dentists and the dental hygienists. It is, for example, highly necessary for interpretations of x-rays, for the design of fillings, for the production of crowns, bridges, and prostheses and to enable a correct occlusion for the patients. It is therefore of great importance for the dental teaching institutions, to not only harbor new knowledge related to this field, but also provide a teaching platform that conveys this knowledge in the best possible way to their students (1).

The teaching institutions of odontology around the world use different approaches in their teaching of tooth morphology. At the University of Oslo (UiO) and the University of Tromsø – The Arctic University of Norway (UiT), tooth morphology is taught by letting the students

interact and visually study human teeth. A plastic bag containing a set of 40 extracted human teeth (32 permanent teeth and the eight deciduous molars) are handed out to each student (Figure 3). Based on discussions with fellow students and instructors, and conferring with a compendium text, lectures and figures, students are supposed to decide and categorize the teeth onto a sheet of paper representing a schematic dentition diagram (Figure 4). Over time it has been shown that some of the extracted teeth are more difficult to categorize than others. This applies, among others, to the premolars in the lower jaw, which based on the characteristics in available literature, cannot be categorized as either 1st or 2nd premolar (6).

Figure 3: Plastic bag containing 40 extracted human teeth (6).

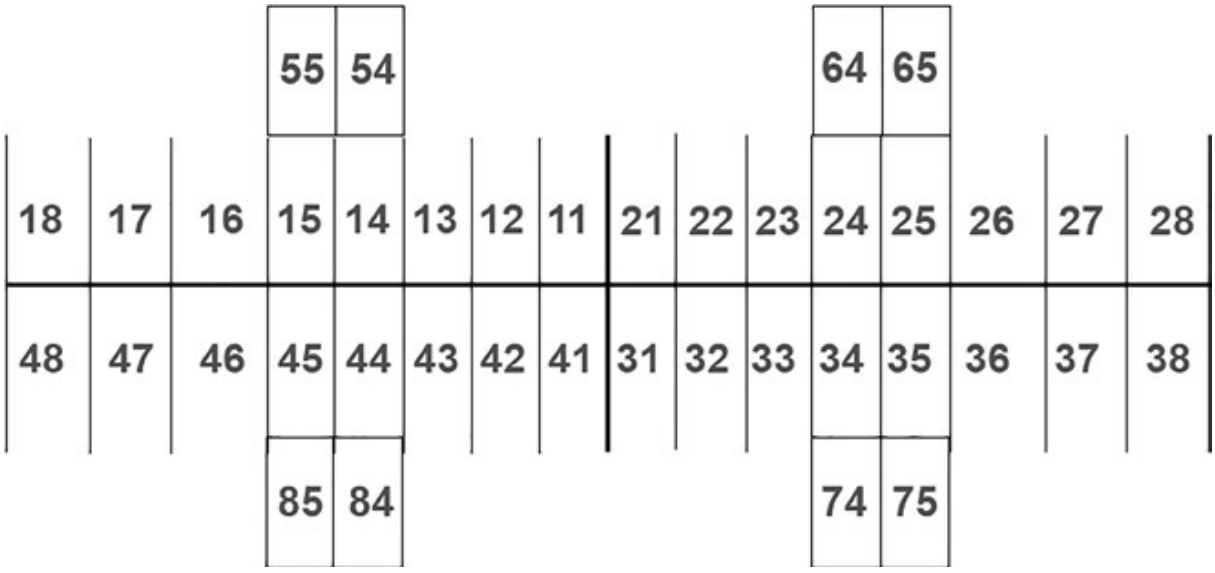


Figure 4: Schematic diagram for categorizing the 40 extracted human teeth (6).

In this project, we map the morphological variations and characteristics of the 1st and 2nd premolars in the lower jaw, so we may add further understanding of why a precise characterization of these teeth is troublesome, and even add novel hypotheses that may ease that task in the future. To do this, we used extracted mandibular premolars from UiT and UiO, as well as dental casts from the Public Dental Service Competence Center of Northern Norway (TkNN).

Material and methods

Literature review

To gather already existing knowledge of the morphological variations of the 1st and the 2nd mandibular premolars, a thoroughly literature research was performed. Anatomical and morphological characteristics were gathered and used to make a solid ground for identification of these teeth. This literature review made basis for generating novel hypothesis about the morphological features regarding 1st and 2nd premolars. In table 1 we have listed out the most common *known* characteristics for them.

Table 1: Overview of the most frequent hallmarks found in the 1st and 2nd premolars (1, 3, 7-10)

	1st Premolars	**2nd Premolars**
Crown	**Occlusal site** Diamond outline Buccal cusp more prominent versus lingual cusp Mesio-lingual groove Two circular fossa separated by crista transversa (distal fossa larger then mesial fossa) Mesio-lingual corner converges towards the middle of the tooth	**Occlusal site** Square outline Mesio-lingual cusp is more prominent than disto-lingual cusp in tricuspid type, and the lingual cusp lingers more to the lingual site Lingual groove in tricuspid type Y- or U-shaped fissure pattern
	Facial site Longer crown Cusp more sharp-pointed	**Facial site** Shorter and wider crown Cusp less sharp-pointed

	Lingual site Narrower compared the facial site Mesio-lingual groove	**Lingual site** Slightly narrower compared to facial site Lingual groove (between the two cusps)
	Approximal site Buccal cusp much higher than lingual cusp Mesio-lingual groove Mesial root depression	**Approximal site** Buccal cusp slightly higher than lingual cusp Mesial site flat or convex
	Crown variation Bicuspid type "Unicuspid type" (the lingual cusp is rather small or almost missing)	**Crown variation** Bicuspid type Tricuspid type Moralization (1st molar mimicking)
Root	Single root Approximal sites converge towards lingual site	Single root Oval shape (cross-section)

Studying of extracted teeth

A total of 493 extracted teeth from UiO and UiT were provided to us. The origin of the teeth were unknown, but had been approved for use in teaching and research by the dentists collecting these. Almost half of the teeth we were given had defects such as fractures, attritions, erosions and/or large fillings, which made it difficult or even impossible to categorize the teeth. Teeth affected by these defects were excluded from the study. The remaining extracted teeth were analyzed and categorized into three different groups (Table 2) by four independent evaluators (two students and two supervisors). In the end, we established an equal amount of 72 teeth in each group, which were agreed upon as "qualitatively suitable" for the task.

Table 2: The categorization of the mandibular premolars done by four evaluators.

Group	Description
A	"Typical" 1st mandibular premolars
B	"Typical 2nd mandibular premolars
C	"Atypical" 1st and 2nd mandibular premolars

As a tool for documentation and support for possible findings, the groups of teeth were separated and photographed. The 72 teeth in each group (Table 2) were divided into 6 subgroups containing 12 teeth, to give us a better overview and improved photo quality. The photographing was performed following these steps:

a) The teeth were stored in 70% alcohol. When needed, thoroughly cleaning and removal of excess remains through mechanical brushing with water was performed.
b) The teeth were photographed from five different dental aspects in their respective groups; mesial, distal, facial, lingual and occlusal plane. Good lighting and camera with high resolution was required. Flash was essential to expose the morphological characteristics in every tooth. A millimeter scale for calibrations was added in every photo.
c) The teeth were arranged in two parallel horizontal rows, with 6 teeth in each row shown in appendix 1. A plastilina model was used in the occlusal plane, and plastilina holders were used in all other planes (mesial, distal, lingual and facial) for equal arrangement of the teeth. All groups were photographed equally by using a stabile tripod.

The camera used for this part of the project was a Sony Alpha A68K SLT + 18-55 mm objective.

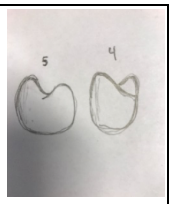
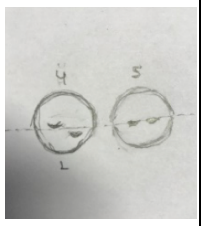
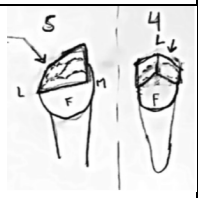
Studying of dental casts

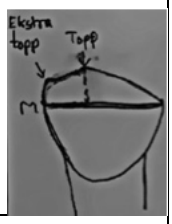
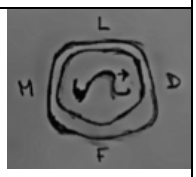
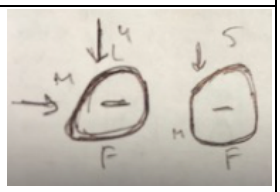
In addition to the extracted teeth, 30 dental casts of Norwegian children at the age of 15 to 18 years old with late mixed and early permanent dentition, was provided by Sigurd Hadler-Olsen, specialist in Orthodontics at TkNN. The two mandibular premolars in each quadrant were photographed from facial, occlusal and lingual site shown in appendix 2. As a supplement, the lower and upper jaw were photographed together from an occlusal view, and at last one photo of each mandibular quadrant was taken in occlusion with the upper jaw from the bilateral facial side. A millimeter scale was placed in each photo for calibration. The camera used for taking these photos was a Nikon D3200 + 18-55 mm objective.

Proposed hypotheses

Eleven hypotheses were formulated and discussed with the supervisor, based on the categorizing and analyzing of the extracted teeth, and after studying the dental casts and photos. The purpose of these hypotheses was to enable categorization of the atypical mandibular premolars, which were initially labeled as ”Group C” (Table 2). The eleven hypotheses were numbered and are presented in table 3 below.

Table 3: Hypotheses overview.

1.	**From an approximal aspect:** The marginal ridge line ends centrally on the 2nd premolar (the tooth drawn to the left), but it continues further towards the lingual aspect on the 1st premolar (the tooth drawn to the right). 
2.	**From an occlusal aspect:** An H-forming pattern is observed in the central groove in the 2nd premolar, but not in 1st premolar.
3.	**From an occlusal aspect:** The central groove makes up two pits. The pits align on a central placed straight line (in a mesio-distal axis) on the 2nd premolar (the tooth drawn to the right), but not in the 1st premolar (the tooth drawn to the left). 
4.	**The “total tilt” of the occlusal plane:** The 2nd premolars display a tilt of its occlusal-plane towards the disto-lingual corner (the tooth drawn on left). This tilt comes in other varieties as flat, lingually or mid-split (the tooth drawn on right) on 1st premolars. 
5.	**From a facial aspect:** There is a trisectional buccal groove on both the 1st and the 2nd premolars. On the 1st premolars, these grooves divide the buccal surface into three even parts (tooth crown drawn on the upper side). On the 2nd premolars, the middle/central part is bigger than the lateral parts. 
6.	**From a facial aspect:** The width is indicated as “b” measured from the tooth’s broadest level when observed from a facial aspect (usually at the level of contact points to the neighboring teeth). The height indicated as “h” is measured from the teeth’s highest incisal edge as a perpendicular line to the width (shown in the drawing). 

	The height is approximately the same as the width on the 1st premolars, but on the 2nd premolars the width is greater than the height. This gives different measurable ratios.
7.	**From a facial aspect:** There is an additional peak on the incisal edge towards the mesial side on the 1st premolar. 
8.	**Cross-sectional observations at the level of cervical margin:** The 1st premolars display a broader facial mesio-distal aspect compared to their lingual side. On the 2nd premolars, these aspects of the facial and lingual sides are approximately the same.
9.	**From an occlusal aspect:** The central groove makes up a mid-portion, which protrudes and curves towards the lingo-distal corner on the 2nd premolars. 
10.	**From an occlusal aspect:**  The linguo-mesial corner lies retracted from its position often in both premolars. On the 2nd premolars, this retraction is mainly from a lingual aspect (indicated as an arrow on the tooth drawn to the right). The retraction on the 1st premolars is observed from both lingual *and* the mesial direction (indicated as two arrows on the tooth drawn to the left).
11.	**From an occlusal aspect:** On the 1st premolars, more facial surface is observable from an occlusal point of view, compared to the 2nd premolars. This may be explained/observed secondary by studying the convex area on the buccal surface, which is placed more towards the cervical margin on the 1st premolars (indicated as an arrow on the lower tooth). The teeth were scores for both features. 

Scoring of hypotheses

The 72 teeth in group C were categorized into 6 subgroups with a total of 12 teeth in every group (Appendix 3). Every tooth in the subgroups where then separated from each other. The background for this system was to easily identify a specific tooth, as we independently (students and supervisor) evaluated every tooth for the 11 hypotheses. The foundation for the evaluation system is presented in table 4.

Table 4: The foundation of the evaluation system.

Sign used to depict the evaluation	**Description of the signs**
1	The tooth is too damaged to score due to attrition, erosions, fractures and/or large fillings
2	No match at all with the hypothesis
3	Unsure
4	The hypothesis matched the 1st premolar
5	The hypothesis matched the 2nd premolar

To score the reliability of a hypothesis, a system based on "strength" was formulated. The strength of each hypothesis would increase if all three of us agreed and scored the tooth to be the same. The evaluation of strength was done in the following way: "certain" 1st or 2nd premolar when all three of us answered the same (Table 5, example nr. 1), "presumable" 1st or 2nd premolar when two of us agreed on type of tooth but the third was not sure (Table 5, example nr. 2), "uncertain" when one of us agreed with our supervisor but the second student scored it as the other premolar, or the two students agreed but the supervisor scored it as the other premolar (Table 5, example nr. 3), and "indefinable" where all of us have answered differently and/or been uncertain (Table 5, example nr. 4). To quantify the strength, results are given as percentage of total number of teeth for each hypothesis, shown in figure 4.

Table 5: Scoring-method for measurement of the strength of a hypothesis by three evaluators

Example nr.	**Supervisor**	**Student 1**	**Student 2**	**Certainty**	**Strength**
1	4	4	4	Certain	Strong
2	4	4	3/2	Presumable	Medium
3	4	4	5	Uncertain	Weak
4	5	4	3/2/1	Indefinable	Weak

Hypothesis 6 and 11 are considered as "comparison hypothesis", which means that any defined proportion between 1st and 2nd premolars can be tested against one another to make statistical analyses. It therefore requires the possibility to visually compare the two types of premolars. To test these hypotheses, two methods were used:

a) The study of extracted teeth in group C (Table 2) plotted in a scoring system.
b) Concrete measurements and analysis of dental casts in advanced data programs.

Method b) was used as basis in this task for more correct analysis and evaluation of data, and method a) was used as supplement. The reason for this is the lack of reliability in method a) as we examine one tooth at a time and cannot compare them.

Photos of dental casts taken from facial and occlusal side in each mandibular quadrant was used in method b) to compare 1st and 2nd premolar considering height and width. The photos were transferred to Adobe Photoshop Lightroom CC 2019. Each photo was calibrated manually by transferring the millimeter scale into pixels. 20 millimeters from the scale was transferred into a number of pixels, which again was transferred into millimeters, unique to every photo. Criterion to carry out individual calibration of the dental casts had to be defined as hallmark, which was recognizable in every photo and relevant to each hypothesis shown in table 6. These hallmarks were used as basis to measure the height and width of the 1st and 2nd mandibular premolar in each quadrant to test hypotheses 6 and 11.

Table 6: Hallmarks overview. Refers to hypothesis 6, which separates 1st and 2nd premolar one from the other, as height and width is measured, and hypothesis 11, which separates 1st and 2nd premolar, as length on the facial side from an occlusal point of view, is measured.

Hypothesis	Hallmarks
6	Width = horizontal (right above the contact point in every dental cast). Height = vertical (top point of incisal edge on every tooth, perpendicular to the horizontal line).
11	Height = Top point of incisal edge (in transition incisal- and occlusal edge) to transition of tooth and/or gingiva, or where the tooth is no longer visible.

Statistics

Extracted teeth

Every tooth went through a scoring system for every hypothesis and was registered in spreadsheets (Excel, Microsoft office for Mac 2011) to enable descriptive statistics. Values are given in percent of all the extracted teeth in group C (Table 2).

Dental casts

Analysis is carried out using spreadsheets (Excel, Microsoft Office for Mac 2011 (Appendix 4)). To compare the means of height, width and width/height-ratios for hypothesis 6 and 11, a Student's T-Test was used. Values are given in mean ± standard deviation.

Results

Extracted teeth

A thorough study of the literature and discussions with the supervisors resulted in exclusion of hypothesis 8, as it came apparent that the major aspects of this already were well documented. However, we decided to keep the initial numbering of the hypotheses given in table 3, and continued with a total of 10 hypotheses.

While studying the extracted teeth, one tooth got damaged and the defect was considered substantial. This tooth was therefore categorized as "indefinable" in every hypothesis tested. This is shown as a red cell in subgroup C6 in appendix 3.

As shown in table 3, some of the hypotheses only apply to either the 1st or 2nd premolar.

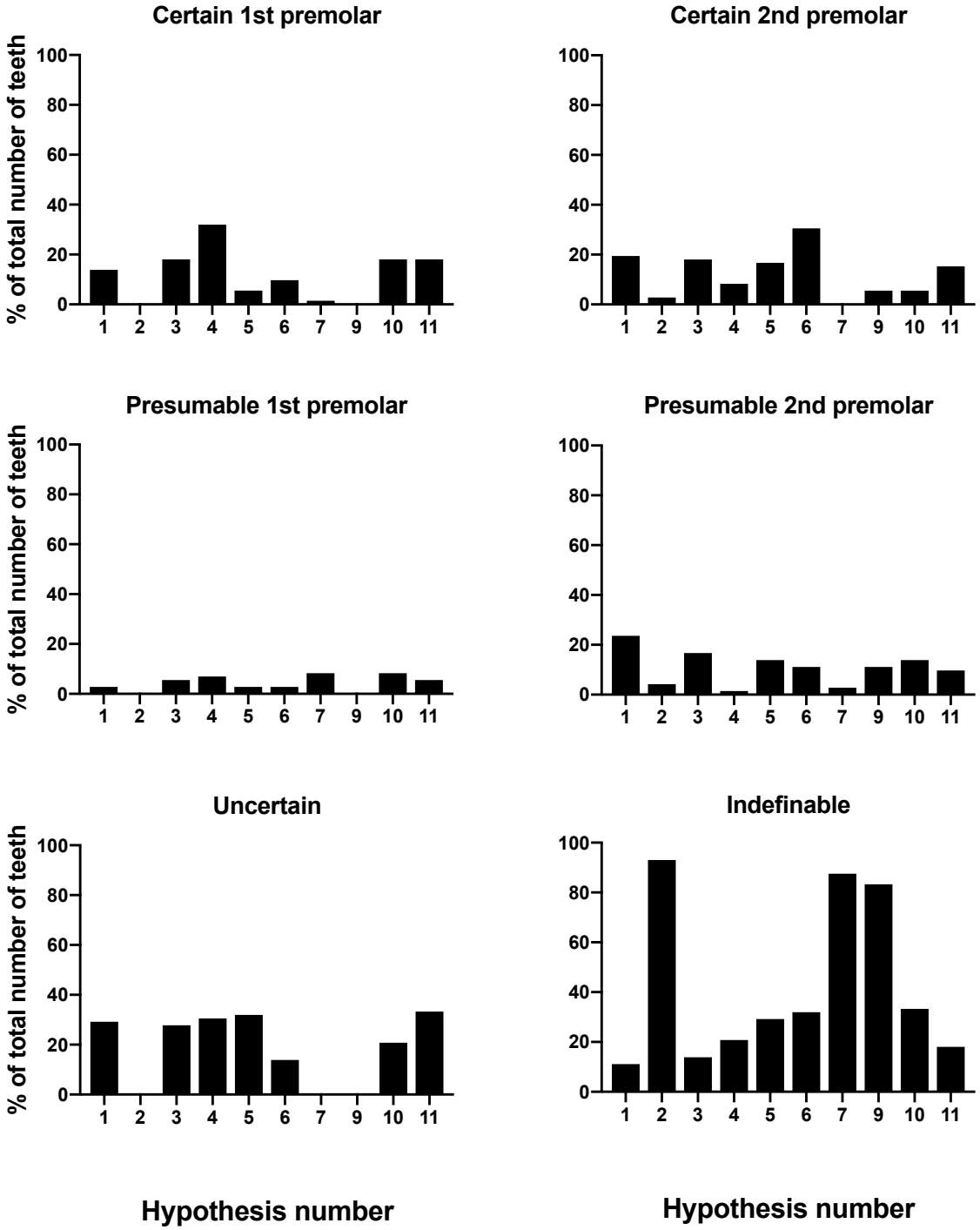


Figure 2: The results from the extracted teeth presented in six bar charts. Each bar represents each hypothesis. Hypothesis 8 has been rejected and is therefore not included in the bar charts. Certain 1st and 2nd premolars: all three evaluators have answered the same. Presumable 1st and 2nd premolars: two of the evaluators agree on type of tooth, but the third is uncertain. Uncertain: One of the students agrees with the supervisor on which tooth it is and the second student thinks it is another tooth, or the two students agrees on which tooth it is and the supervisor thinks it is another tooth. Indefinable: All of the evaluators have answered differently and/or been uncertain. The results are given in percentage of total number of teeth.

Table 7: Usefulness of the hypotheses. The first column represents the hypotheses. The second column shows a total of teeth scored either certain or presumable 1st and/or 2nd premolars. The third column shows the values related to either uncertain or indefinable teeth. The results are given in percentage. The hypotheses evaluated as useful for further evaluation are colored green.

Hypothesis number	**The percentage that was scored as "certain" and "presumable" premolars**	**The percentage that was scored as "uncertain" or "indefinable" premolars**
1	60	40
2	7	93
3	58	42
4	49	51
5	39	61
6	54	46
7	13	86
9	17	83
10	46	54
11	49	51

In hypothesis 1, the percentage that makes up certain 1st and 2nd premolars in total is 33. Adding the number of teeth scored as presumable 1st and 2nd premolars provides a total percentage of 60. The group scored either as uncertain (29%) or indefinable (11%) makes up the rest of 40%. This hypothesis may therefore be used to identify 60% of the atypical premolars group, with medium to high certainty.

For hypothesis 2, which applies only for the 2nd premolars, the total percentage of indefinable teeth is very high, 93%. We only manage to identify 7% of the certain and presumable 2nd premolars. The hypothesis will therefore be of low quality.

Hypothesis 3 is almost as strong as hypothesis 1. The total percentage of certain and presumable 1st and 2nd premolars is 58, and 42% makes up the uncertain and indefinable teeth. Hypothesis 3 may therefore be used to identify 58% of the atypical premolar groups, with medium to high certainty.

The results for hypothesis 4, 5 and 6 all show that they are of medium quality. For hypothesis 4 the total value of certain and presumable 1st and 2nd premolars are 49%. For hypothesis 5 the corresponding value is 39%, and 54% for hypothesis 6.

Hypothesis 7 can be used to identify 13% of the atypical 1st premolars. There is no uncertainty, but the percentage of indefinable teeth is 86, and the hypothesis can therefore be considered to have low quality.

Hypothesis 9 can be used to identify 17% of the atypical 2nd premolars. There is no uncertainty, but the percentage of indefinable teeth is 83, and the hypothesis can therefore be considered to have low quality.

The results for hypothesis 10 and 11 show that they are of medium quality. For hypothesis 10 the total percentage of certain and presumable 1st and 2nd premolars were 46. For hypothesis 11 the corresponding value is 49%.

Dental casts

In total there were 30 dental casts from 30 patients, in the age between 15 to 18 years old with late mixed- and permanent dentition, which were used to test hypothesis 6 and 11. In hypothesis 6 the total amount of 1st and 2nd premolars differ due to exclusion of 1 tooth. Rotation of one premolar in one quadrant made it impossible to do measures on the tooth, thus the reduced number of teeth in the group of 1st premolars versus 2nd premolars in table 8. In hypothesis 11 a total of 29 dental casts was studied shown in table 9. The photo projection of one model of the dental casts in the occlusal plan was too deviated to accomplish optimal measures and it had to be excluded.

*Table 8: Width = horizontal; right above the contact point in every dental cast. Height = vertical; top point of incisal edge on every tooth, perpendicular to the horizontal line. Values are presented as mean ± standard deviation. * p<0.05 (Student's T-Test).*

	Hypothesis 6 (n = 30)	
	1st premolar (n = 59)	2nd premolar (n = 60)
Pixels per 20 mm	1701 ± 169	
Width (mm)	7.0 ± 0.4	7.0 ± 0.5
Height (mm)	2.6 ± 0.4	2.1 ± 0.3*
Ratio (width/height)	2.8 ± 0.4	3.3 ± 0.5*

*Table 9: Height = vertical; top point of incisal edge to transition of tooth and/or gingiva, or where the tooth is no longer visible. Values are presented as mean ± standard deviation. *p < 0.05 (Student's T-Test).*

	Hypothesis 11 (n = 29)	
	1st premolar (n = 58)	2nd premolar (n = 58)
Pixels per 20 mm	2067 ± 358	
Height (mm)	2.7 ± 0.9	3.1 ± 0.8*

Discussion

Tooth anatomy and morphology is a discipline in odontology, which is essential for any occupation that engages in dental and oral health issues. In this study, we have aimed to improve the mapping and definitions regarding mandibular premolars in the aspects of tooth morphology. Thus, we formed eleven hypotheses (hypothesis 8 was excluded as mentioned earlier) that were discussed and evaluated systematically using extracted teeth and dental casts. The goal of this project was to find novel characteristics, and easier describe the premolars and distinguish the 1st from the 2nd.

Hypotheses

Hypothesis 1, which includes both 1st and 2nd premolars, has the highest percentage of certain and presumable 1st and 2nd premolars, compared to all the other hypotheses. This, combined with a low quantity of indefinable teeth, makes hypothesis 1 the strongest of them all. The outcome for this can be explained by the agreement among the three evaluators, which reflects the distinctness of a feature on one tooth.

Unlike hypothesis 1, hypothesis 2 applies to only the 2nd premolars. Therefore, no values for 1st premolars are shown in figure 4. Hypothesis 2 has the greatest value of indefinable teeth, which means that the features we were looking for simply have not been present. The percentage of uncertainty equals zero, which is good as there is no uncertainty among the evaluators that can affect the results. Values for both certain and presumable 2nd premolars are low, which may suggest that the hypothesis is weak, and should therefore be rejected. But it is in fact true that a very small amount of the teeth have this feature, as we discovered that the H-forming pattern has also been described in earlier literature as a rare hallmark (2), which

might strengthen the possible use of this characteristic when looking for certain 2nd premolars. As an example to this oddity, molarization of mandibular premolars which also is a rather rare sign, seem unique for 2nd premolars (8).

Hypothesis 3 incorporate both 1st and 2nd premolars. The total value for both the certain and presumable 1st and 2nd premolars are quite high, which means that the features we are looking for is present. The amount of uncertain and indefinable premolars is less than half of the total number of teeth. Thus, this hypothesis stands out as the second strongest of them all.

Both 1st and 2nd premolars are included in hypothesis 4. The total score for uncertain and indefinable teeth have approximately the same percentage as the certain and presumable teeth. Figure 4 shows that this hypothesis has the highest score for certain 1st premolars of all the hypotheses, which reflects the feature as more commonly observed in 1st premolars than in 2nd premolars.

Hypothesis 5 applies to both 1st and 2nd premolars. Similar to hypothesis 4, the total score for uncertain and indefinable teeth, compared to certain and presumable teeth, are approximately the same. Unlike hypothesis 4, figure 4 shows that features in hypothesis 5 are observed more often in 2nd premolars versus 1st premolars.

As previously mentioned, hypothesis 6 is considered to be a comparison hypothesis, and refers to 1st and 2nd premolars. The measurements done on the dental casts makes it possible to compare the 1st and the 2nd premolars, as they both are present in the dental arch. The same conditions were not achievable for the extracted teeth since we visually analyzed one tooth at a time. Despite this, the teeth in group C (Table 2) were scored by the three evaluators. The reliability of this hypothesis, taken the extracted teeth into consideration, was therefore considered as rather week based on its limitation, and the dental casts therefore emphasize the results. The results from hypothesis 6 regarding the dental casts show great measure difference in width and height in the two groups of premolars (Table 7). The analysis and data shows that the width and height in 1st premolar are *not* approximately the same, which means that hypothesis 6 contradicts itself. On the other side, results show that the width is greater than the height in 2nd premolars, which corresponds to our hypothesis. Interestingly, the analysis of the dental casts shows a significant difference in height regarding 1st and 2nd premolars. The 2nd premolars are significantly lower compared to 1st premolars. In addition, the ratio between width and height in the two groups of premolars are different because of the

height difference. The ratio between width and height is significantly greater in 2nd premolars compared to 1st premolars.

Since hypothesis 7 only applies to 1st premolars, there should be no results for the 2nd premolars in our analysis, but figure 4 tells us otherwise. There are no results for certain 2nd premolars, but there is a low score on presumable 2nd premolars. The reason for this may have been our lack of consistency while scoring the teeth, in example, where we should have categorized the teeth in our evaluation system (Table 4) as 1, 2, 3 or 4 regarding the 1st premolars, we evaluated the teeth to be categorized as a 5 as well, which reduces the hypothesis reliability. This hypothesis has the second highest score of indefinable teeth, which means that the feature is rarely observed and the hypothesis appears quite weak. Interestingly enough the feature is still observed and may appear as a rare observation, similar to the H-pattern in hypothesis 2.

Hypothesis 9 applies only for the 2nd premolars. Unlike hypothesis 7, there are no percentage given for the certain and presumable 1st premolars. There is a quite low percentage for both certain and presumable 2nd premolars, which reflects the insufficient observation of the defined feature. Similar to hypothesis 7, this hypothesis has the third highest percentage of indefinable teeth.

Both 1st and 2nd premolars are incorporated in hypothesis 10. The values for uncertain and indefinable teeth weighs up for the certain and presumable premolars, which results in that the hypothesis presents as rather weak or moderate in strength.

Since hypothesis 11 is also a comparison hypothesis, which includes both 1st and 2nd premolars, the basis for analysis and measurements were based on the same analysis and measurements carried out in hypothesis 6. The difficulty of transferring the same conditions from the dental casts, while studying the extracted teeth, is reflected in the results for uncertain premolars (Figure 4). The percentage of uncertain premolars is high compared to other hypotheses. We believe that the results have been influenced by the limitations linked to the visual scoring of the teeth.
The results for the dental casts show a difference in height (length on the facial side from an occlusal point of view) between 1st and 2nd premolar. Interestingly, the analysis shows a significant difference, as the height in 2nd premolar compared to 1st premolar, is greater. The results then contradict hypothesis 11. The measures done for analyzing the dental casts,

compared to the visual scoring of the extracted teeth, will therefore not match. Comparing the results regarding extracted teeth and dental cast will in this case be misleading.

Limitations

Although we here present some interesting results in our study, bias, errors and other limitations may still have influenced many aspects.

Even though 72 teeth were handpicked based on their morphological qualities, some of these still displayed different degrees of erosions, attritions, fractures and fillings. Also, because all four evaluators carried out the initial sorting, we cannot totally exclude the possibilities of error in this process.

Another aspect that is important is that a slight change in angling of the tooth would have a great effect on how the three evaluators would score the tooth. The decisions are made "by eye" and hence lack digital standardization. This is also true for the photographing. Both the extracted teeth and dental cast have been photographed from different angles. The projection on the camera, the definition of reference points and manually measurements may all contain errors, influencing the outcomes of anatomical and morphological variations as rotation of teeth, lingual or buccal tipping, spacing, crowding and contact points.

The issue with contact points is especially important regarding hypothesis 6 and 11. The measurements are based on the definition of reference points to height and width, which means that the results will differ from one another if the reference points changes. The reference point for width on the dental casts, for example, were sat to be right above the contact point of the neighboring teeth. Transferring the same reference points to the extracted teeth while scoring them was impossible without any neighboring teeth. This implemented the use of eye measurements, and has influenced our results.

The weakness of this study provides the basis for improvement. The selection of teeth in the study could have been of better quality (i.e. less damaged teeth). It might also have been advantageous to use an even larger number of evaluators, so that the average response would be more reliable.

The sorting of the "typical" 1st and 2nd premolars" should have been labeled at the time of tooth extraction, assuring a more correct outset. Interpretation of our results shows that more

precise and optimal methods for measures can be done. For the extracted teeth, the use of a digital caliper would make the measurements of the width more reliable (11). Another tool that would make the analyzing more precise for both the dental casts and the extracted teeth is the use of digital computer programs (i.e. CBCT or O3DM software program) (12). These programs would make it possible to recreate the exact same angle of all the teeth, defining the precise reference points for every tooth, and hence providing more reliable measurements.

Other findings

As this project developed, some surprising observations were made and are worth discussing. A population of the extracted premolars evaluated for this study displayed extensive attrition and/or tooth wear. The amount of wear (buccal, lingual, occlusal, bucco-mesial, bucco-distal) that affected the teeth often involved multiple sides on the 1st premolars, but most often only one side (either occlusal or facial) on the 2nd premolar. The preliminary data is presented in the table below.

Table 10: Overview of attrition and tooth wear regarding 1st and 2nd premolars.

Tooth wear pattern	One side affected	Two sides affected	Three or more sides affected	Total
1st Premolar	6	5	10	22
2nd Premolar	17	4	1	22

This is an interesting finding, as it hypothesizes the 1st premolars usage of both grinding (occlusal wear) and cutting (buccal, bucco-mesial and bucco-distal wear), hence underlining its specialization in function as unique. This hypothesis should be further tested in micro-CT facilities and on a larger teeth sample.

Conclusion

Most of the 10 hypotheses we formulated and tested did not seem to aid the aims that were set for this study, confirming the problem with premolar-morphology. However, hypotheses 1, 3, 6 and 11 are evaluated as useful. Hypothesis 1 is considered the strongest one from the categorization of extracted teeth, and hypothesis 3 as the second strongest. The testing of hypotheses 6 and 11 provides very interesting information about the relation between height

and width for the mandibular premolars. Based on the results and the limitations, we conclude that these hypotheses should remain interesting for further research, along with the findings of tooth-specific wear.

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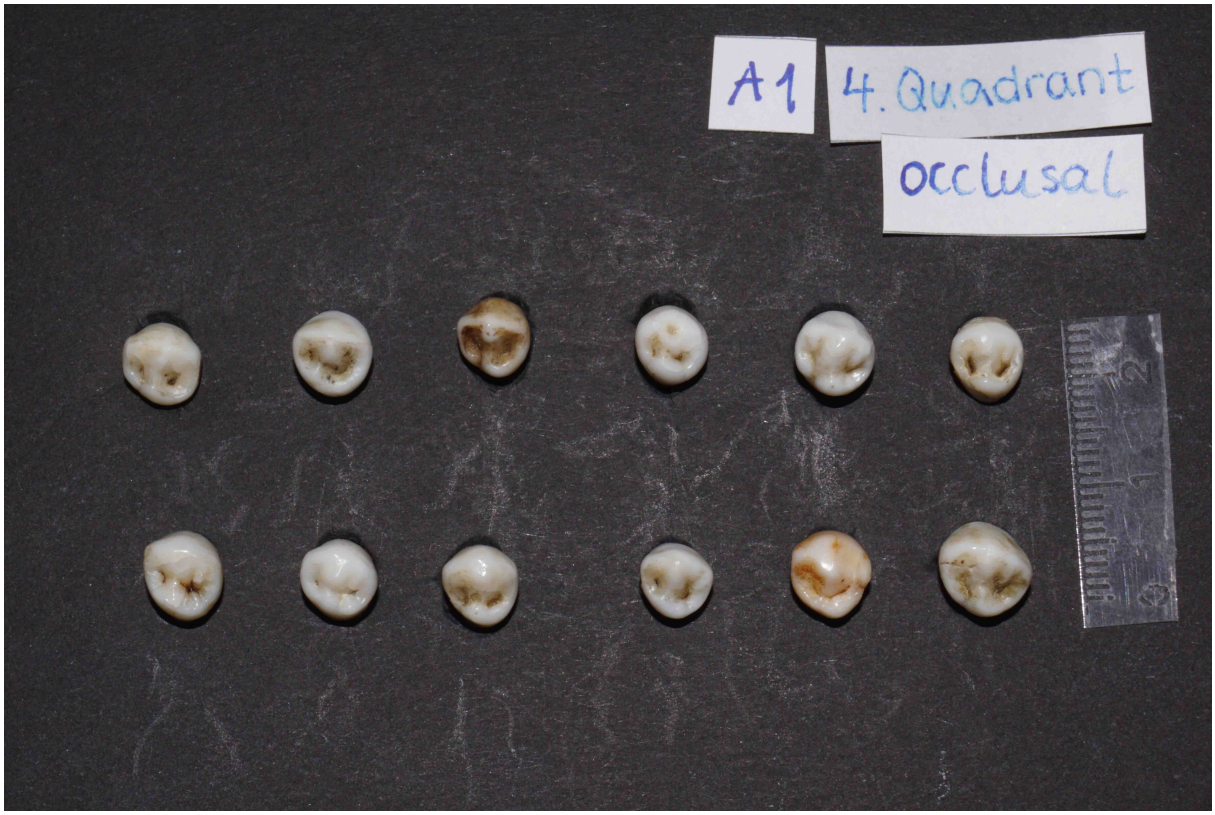
Appendices

Appendix 1



Appendix 1, figure 1: Extracted teeth in group A from occlusal plane.

Appendix 1, figure 2: Extracted teeth in group A from lingual plane.

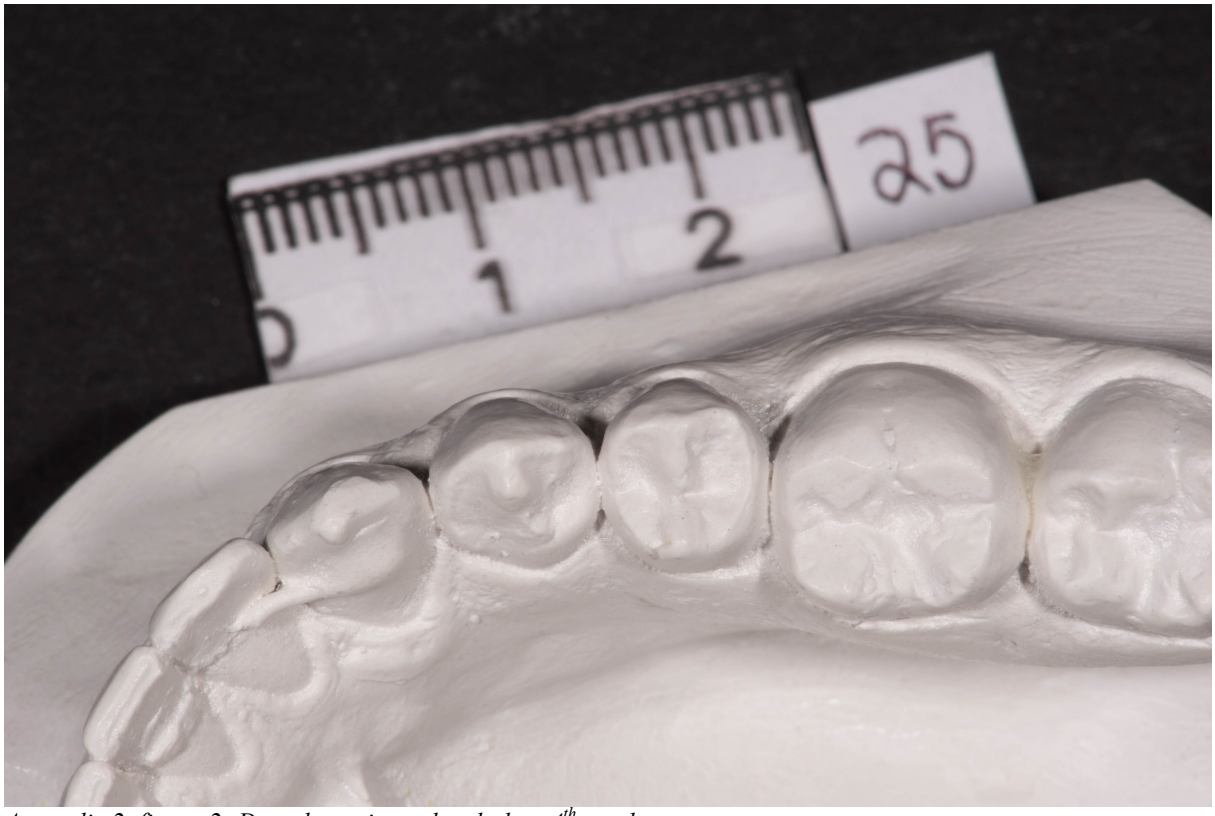
Appendix 1, figure 3: Extracted teeth in group A from facial plane.

Appendix 1, figure 4: Extracted teeth in group A from distal plane.

Appendix 1, figure 5: Extracted teeth in group A from mesial plane.

Appendix 2

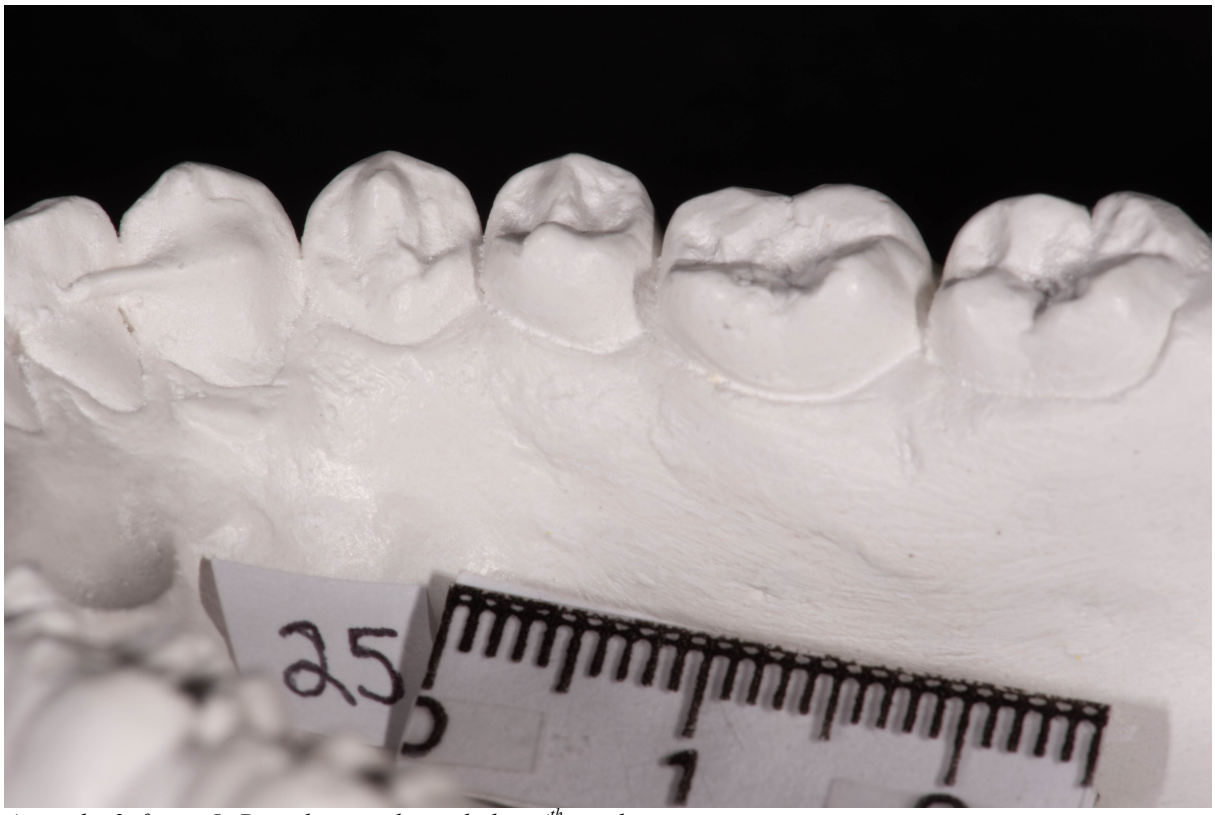
Appendix 2, figure 1: Dental cast in occlusal plan, 3rd quadrant.



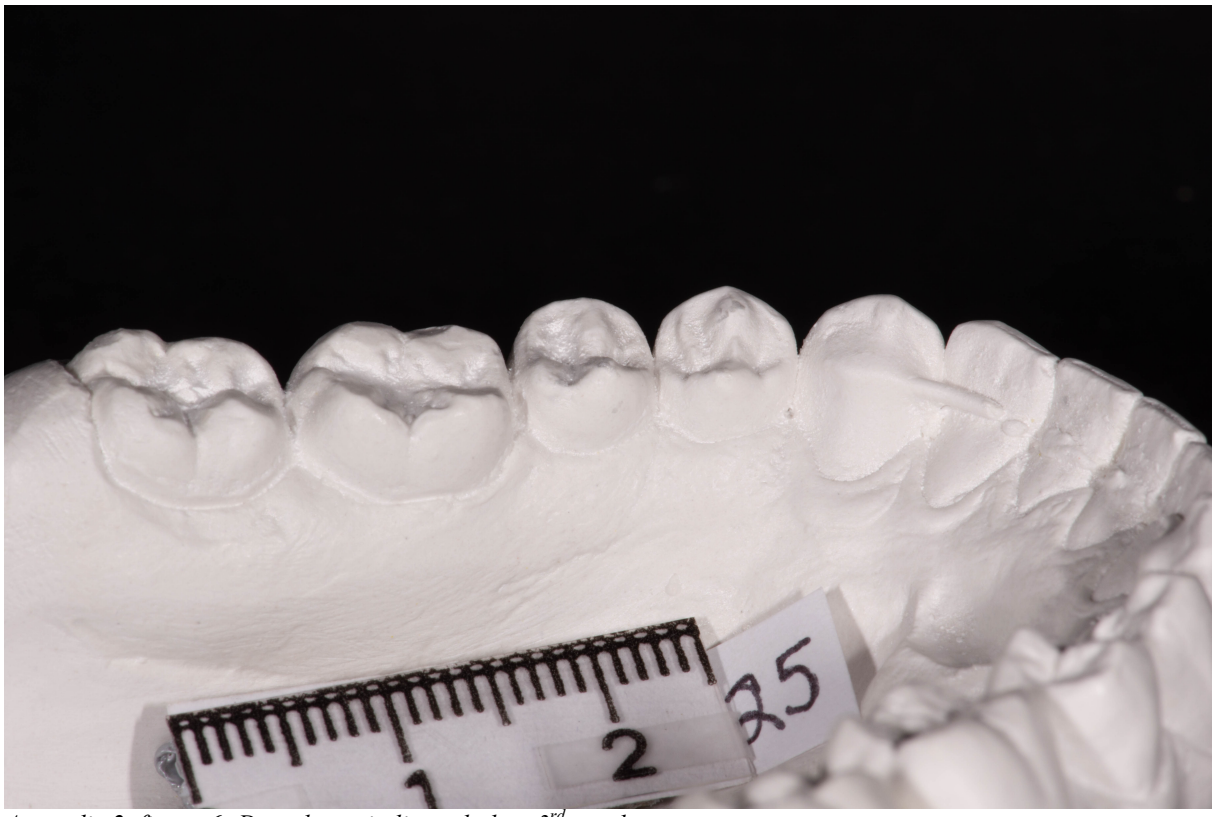
Appendix 2, figure 2: Dental cast in occlusal plan, 4th quadrant.

Appendix 2, figure 3: Dental cast in facial plan, 4th quadrant.

Appendix 2, figure 4: Dental cast in facial plan, 3rd quadrant.



Appendix 2, figure 5: Dental cast in lingual plan, 4th quadrant.



Appendix 2, figure 6: Dental cast in lingual plan, 3rd quadrant.

Appendix 3

Hypotese 1

	C1			C2			C3			C4			C5			C6		
Tann	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa
1	5	4	5	5	5	4	5	4	5	5	5	3	5	5	5	5	5	3
2	5	5	2	5	5	4	5	5	5	5	5	3	4	4	4	5	5	5
3	5	5	5	5	5	4	5	5	3	5	5	5	5	5	3	5	5	5
4	5	5	5	5	5	3	5	5	4	4	4	4	5	4	4	4	5	4
5	4	5	3	5	5	3	4	4	4	5	5	3	4	5	4			
6	5	5	5	5	5	4	5	1	4	5	5	3	4	4	4	4	5	4
7	5	5	5	5	5	4	4	4	4	5	4	4	5	3	4	5	5	4
8	5	5	5	5	5	3	5	5	3	4	5	3	5	5	4	5	5	5
9	5	5	5	4	4	4	5	5	3	5	5	5	5	5	3	4	5	3
10	5	5	4	4	5	3	5	5	3	4	4	3	5	5	4	5	5	4
11	5	5	5	5	5	3	4	4	4	4	4	3	4	4	4	5	5	4
12	4	4	4	5	5	4	4	4	4	5	5	3	5	3	3	5	5	4

Hyptoese 2

	C1			C2			C3			C4			C5			C6		
Tann	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa
1	2	2	2	2	2	2	2	2	2	5	5	5	2	2	2	2	5	5
2	5	5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	2	2	2	2	2	2	2	2	5	2	2	2	2	2	2	2	2	2
4	2	2	2	5	5	5	2	2	2	2	2	2	2	2	2	2	2	2
5	2	2	2	5	2	5	2	2	2	2	2	2	2	2	2			
6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
7	2	2	5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
8	2	2	5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
9	2	2	2	2	2	2	2	2	2	2	2	2	2	2	5	2	2	2
10	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	5	5
11	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
12	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	5

Hypotese 3

	C1			C2			C3			C4			C5			C6		
Tann	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa
1	5	4	5	4	5	4	5	2	4	5	5	5	5	5	5	2	5	5
2	5	2	4	4	5	5	4	4	4	4	4	4	4	4	4	2	5	5
3	4	4	4	1	5	4	4	4	5	5	5	5	4	5	3	2	5	5
4	5	5	5	1	5	5	4	5	4	5	4	4	3	4	4	4	4	4
5	4	4	4	1	5	5	1	5	4	4	5	3	5	5	5			
6	5	4	4	1	5	4	4	5	5	5	5	5	4	4	3	4	4	4
7	5	5	5	4	3	4	4	5	5	5	5	5	4	4	4	5	5	3
8	2	5	5	5	3	4	4	4	4	4	4	4	5	5	5	5	5	3
9	1	5	5	4	4	5	4	4	4	5	4	3	4	5	5	4	5	5
10	1	5	5	4	4	4	5	5	5	4	4	4	5	5	5	4	5	5
11	4	5	5	2	5	5	5	5	5	4	4	5	2	4	4	5	5	5
12	2	5	5	4	4	5	5	5	4	4	5	5	5	5	4	5	4	5

Appendix 3, figure 1: A schematic overview of the results after 72 teeth in group C have been evaluated by two students and one supervisor. The results are from hypothisis 1, 2 and 3.

Hypotese 4

	C1			C2			C3			C4			C5			C6		
Tann	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa
1	5	5	5	4	4	4	4	4	4	4	5	5	4	5	4	4	5	5
2	3	5	4	3	4	4	3	5	5	4	4	4	4	4	4	1	1	5
3	3	5	4	1	5	4	4	5	5	4	4	4	4	5	5	4	5	4
4	1	1	2	4	4	5	4	5	4	4	4	4	4	4	4	4	5	1
5	4	4	4	4	4	4	5	4	4	4	4	4	5	5	5			
6	4	4	5	4	4	4	4	1	4	4	4	5	4	4	5	4	5	5
7	4	4	4	1	1	3	4	1	4	5	4	4	4	4	4	5	5	5
8	4	4	4	4	5	4	4	5	5	4	4	3	4	1	5	5	5	5
9	4	5	3	4	4	4	1	1	4	4	5	5	4	4	4	4	4	4
10	4	4	5	4	1	4	4	5	5	4	4	4	4	4	4	5	5	5
11	4	4	4	5	5	5	4	5	4	4	1	5	4	4	4	1	4	4
12	4	4	4	5	1	4	4	5	4	4	1	4	4	5	4	4	4	4

Hypotese 5

	C1			C2			C3			C4			C5			C6		
Tann	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa
1	4	4	5	4	5	3	4	4	3	5	5	5	5	5	3	4	5	5
2	5	5	1	5	5	5	4	5	5	4	1	4	4	4	4	1	1	1
3	4	5	3	5	5	4	4	5	3	5	5	3	5	5	3	5	5	5
4	1	1	5	5	5	5	5	5	5	4	5	4	5	5	4	1	1	4
5	5	1	2	5	5	3	5	4	4	5	5	1	4	5	5			
6	5	4	5	5	5	5	4	4	4	5	5	5	5	5	1	5	5	4
7	5	4	4	1	1	4	1	1	4	5	3	4	5	4	1	1	5	1
8	4	5	4	4	5	4	5	5	5	4	1	3	5	1	3	5	5	5
9	5	5	5	5	4	5	1	1	1	4	5	5	4	5	3	5	5	4
10	5	5	5	1	5	4	5	5	4	5	1	5	5	5	4	5	5	5
11	5	5	4	4	5	5	5	5	4	5	1	5	4	4	4	1	5	5
12	4	4	4	1	1	1	1	3	4	1	1	1	5	5	4	5	5	4

Hypotese 6

	C1			C2			C3			C4			C5			C6		
Tann	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa
1	5	5	5	4	4	4	4	5	3	5	5	5	5	5	5	5	5	5
2	5	5	4	5	1	5	1	5	5	4	4	4	1	1	4	1	5	1
3	5	5	4	5	1	4	5	5	3	1	5	1	5	5	5	5	5	5
4	1	1	3	5	5	5	5	5	3	4	4	4	5	5	5	1	1	1
5	5	1	4	5	5	5	4	4	4	5	5	1	5	4	5			
6	5	5	5	5	5	5	4	1	4	5	5	5	5	5	3	5	1	1
7	5	4	4	1	1	1	1	1	4	5	4	4	4	4	4	5	5	5
8	4	5	4	5	4	4	5	5	5	5	4	1	1	1	1	5	5	5
9	5	5	5	4	3	5	1	1	1	5	5	5	4	5	5	5	5	5
10	5	5	5	1	5	4	5	5	5	5	1	4	5	5	5	5	5	5
11	5	5	1	4	5	5	1	5	1	1	1	5	4	4	4	1	5	1
12	4	4	4	4	5	5	1	4	4	1	1	1	1	5	5	5	5	1

Appendix 3, figure 2: A schematic overview of the results after 72 teeth in group C have been evaluated by two students and one supervisor. The results are from hypothisis 4, 5 and 6.

Hypotese 7

	C1			C2			C3			C4			C5			C6		
Tann	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa
1	3	5	4	3	5	4	2	2	2	2	2	4	1	2	4	2	2	4
2	2	2	2	1	1	2	1	2	2	2	1	3	1	2	4	1	2	1
3	5	2	4	1	5	3	2	2	2	1	2	2	1	2	2	2	2	4
4	1	1	2	5	5	2	2	4	2	2	4	4	2	4	4	1	1	1
5	4	1	4	2	5	2	2	2	3	1	2	1	1	2	1			
6	5	2	5	2	5	4	4	4	4	1	2	2	1	2	3	2	2	1
7	2	2	4	1	1	1	1	1	3	2	4	4	2	2	3	2	4	3
8	4	2	4	2	5	4	2	2	3	2	2	4	1	2	1	2	4	2
9	1	2	2	2	2	4	1	1	1	2	2	3	2	2	4	2	2	4
10	2	2	5	1	1	1	2	2	2	2	2	3	2	2	4	2	2	2
11	1	2	2	2	5	4	1	2	4	1	2	1	2	4	4	1	2	1
12	2	4	2	1	1	3	1	1	2	1	2	1	2	2	4	2	2	2

Hypotese 9

	C1			C2			C3			C4			C5			C6		
Tann	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa
1	2	2	5	2	2	2	5	2	2	2	2	2	5	5	5	2	2	2
2	2	5	4	2	2	5	5	5	5	2	2	2	2	2	2	2	2	2
3	2	2	5	5	2	2	2	5	5	2	2	3	2	2	5	2	5	2
4	2	2	4	2	2	2	2	2	5	2	2	2	5	5	3	2	2	2
5	4	2	2	5	2	2	3	2	2	2	2	2	2	2	2			
6	2	2	2	3	2	2	2	2	2	5	2	5	2	2	3	2	2	2
7	2	2	3	2	3	3	2	2	5	5	2	2	2	2	3	5	5	2
8	2	2	4	5	5	5	2	2	3	2	2	2	2	2	2	2	2	2
9	5	5	5	2	2	4	2	2	5	2	5	5	2	2	2	2	5	2
10	5	5	2	2	2	4	5	5	2	2	2	2	2	2	2	2	2	2
11	2	2	4	3	5	2	2	2	2	2	2	2	2	2	2	2	3	2
12	2	2	2	2	2	3	2	2	2	2	2	2	5	5	2	2	2	2

Hypotese 10

	C1			C2			C3			C4			C5			C6		
Tann	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa
1	5	2	5	4	5	4	5	4	3	5	4	3	5	5	3	4	5	4
2	4	4	3	2	5	4	4	5	5	5	5	5	4	4	4	3	3	5
3	4	4	4	2	5	3	4	4	5	5	2	5	5	4	4	2	2	3
4	3	4	3	2	5	5	5	4	4	4	4	4	2	2	4	4	5	4
5	4	5	4	5	5	5	5	4	4	5	2	3	5	5	5			
6	4	5	5	2	5	5	1	1	3	5	2	5	4	4	4	4	4	5
7	2	2	3	4	5	3	4	4	3	4	4	4	4	4	4	5	5	5
8	2	2	2	4	3	4	5	5	4	4	4	4	4	2	5	5	2	5
9	2	2	5	4	5	3	4	3	5	4	1	5	4	4	4	4	5	5
10	2	4	1	4	4	4	2	3	3	5	4	4	5	2	3	4	5	2
11	4	4	3	4	2	3	4	5	3	4	4	4	4	4	4	2	4	4
12	4	4	4	4	2	5	4	3	4	2	2	5	4	4	5	4	4	4

Appendix 3, figure 3: A schematic overview of the results after 72 teeth in group C have been evaluated by two students and one supervisor. The results are from hypothisis 7, 9 and 10.

Hypotese 11

	C1			C2			C3			C4			C5			C6		
Tann	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa	Su	Ma	Qa
1	4	4	4	4	5	4	4	4	4	4	5	5	5	5	4	4	5	4
2	3	5	4	4	5	3	4	4	4	4	5	4	4	4	4	4	5	5
3	4	5	4	5	5	4	4	4	3	4	5	3	5	5	4	5	5	3
4	5	1	4	5	5	3	5	5	3	4	4	4	5	5	4	4	1	4
5	4	5	4	5	5	3	4	4	4	5	5	3	5	5	5			
6	5	5	5	5	5	4	4	4	4	5	5	5	4	1	3	4	4	3
7	5	5	5	5	5	4	4	4	5	5	4	3	3	1	1	1	5	1
8	4	5	4	4	5	4	5	5	1	5	4	3	5	5	4	5	5	5
9	5	5	5	4	4	4	5	5	5	4	5	3	4	5	4	5	4	5
10	5	5	5	4	5	4	5	5	4	4	4	4	5	5	5	4	4	4
11	4	5	3	5	5	3	4	5	4	4	4	5	4	4	4	5	5	5
12	4	4	4	4	5	3	4	4	4	5	5	5	5	5	4	4	4	3

Appendix 3, figure 4: A schematic overview of the results after 72 teeth in group C have been evaluated by two students and one supervisor. The results are from hypothisis 11.

Appendix 4

	3.kvad.					4.kvad.				
		Tann 4		Tann 5			Tann 4		Tann 5	
	Pixler/20mm	Bredde (mm)	Høyde (mm)	Bredde (mm)	Høyde (mm)	Pixler/20mm	Bredde (mm)	Høyde (mm)	Bredde (mm)	Høyde (mm)
Pas. 1	2126	6,9	2,5	7,1	2,1	2052	6,8	2,4	6,8	2,3
Pas. 2	1805	7,3	2,4	6,8	2,2	1664	7,3	2,5	7,2	2,3
Pas. 3	1806	7,2	2,9	6,8	2,3	1939	7,2	2,9	7,1	2,2
Pas. 4	1729	6	2,1	6,2	1,9	1824	6,2	2,3	6,1	2
Pas. 5	1647	6,9	2,4	6,3	1,7	1877	6,6	2,4	6,5	1,6
Pas. 6	1752	6	1,9	6,9	1,9	1679	6,8	1,8	7,1	2,2
Pas. 7	1673	7,5	3	8,3	2,8	1445	7,6	3,4	7,9	2,5
Pas. 8	1619	7	3,3	6,7	2,1	1653	7,1	3,1	6,7	2,4
Pas. 9	1792	7,2	2,8	7,3	2,2	1545	7	2,6	7,3	2,4
Pas. 10	1818	6,9	2,2	6,9	1,9	1672	6,8	3	7	2
Pas. 11	1621	7,3	2,4	7,6	2	1421	7,3	2,7	7,5	2,1
Pas. 12	2044			7,2	2,5	1828	7,4	2,9	7,5	2,5
Pas. 13	1730	6,7	2,1	6,9	1,9	1834	6,8	2,2	6,7	2
Pas. 14	1687	6,9	2,3	6,9	2,1	1488	6,7	2,7	6,4	2,4
Pas. 15	1592	6,9	2,5	6,5	1,9	1462	7	2,6	6,7	2,2
Pas. 16	1614	6,4	2,7	7,1	2,5	1461	7	2,5	6,6	2,2
Pas. 17	1985	8,1	3,8	7,7	2,7	2011	7,7	2,8	7,5	2,4
Pas. 18	1880	7,2	2,6	7,2	2,1	1917	7,1	2	7	2,2
Pas. 19	1313	7,5	2,8	8,1	2,3	1668	8,3	2,6	7,7	2,1
Pas. 20	1574	6,9	2,3	6,8	1,9	1785	7,3	2,6	7,2	2
Pas. 21	1482	6,9	2,3	6,6	2,1	1613	7,2	2,2	6,7	2,4
Pas. 22	1699	7,2	2,5	7,3	2,2	1701	7,2	2,5	7	2,1
Pas. 23	1931	7,1	2,2	6,6	1,6	1596	7,1	2,3	6,6	1,9
Pas. 24	1565	7,1	2,1	7,5	2	1662	7,2	2,1	7,7	1,8
Pas. 25	1604	6,6	2,9	7	2,3	1796	6,8	2,7	6,6	2,3
Pas. 26	1502	6,4	2,1	6,6	1,8	1612	6,5	2,1	6,2	1,9
Pas. 27	1846	6,9	2,5	6,5	1,2	1631	6,5	2,6	6,6	1,8
Pas. 28	1614	7,3	3,1	7,1	2,6	1652	7,2	3	7	2,5
Pas. 29	1637	6,7	2,6	6,5	2	1662	6,6	2,4	6,5	2
Pas. 30	1541	7,1	3,2	7,4	1,9	1705	7,1	2,7	7,5	2,4

Appendix 4, figure 1: Overview from results after measurements on dental casts regarding hypothesis 6.

	3.kvad.			4.kvad.		
		Tann 4	Tann 5		Tann 4	Tann 5
	Pixler/20mm	Høyde (mm)	Høyde (mm)	Pixler/20mm	Høyde (mm)	Høyde (mm)
Pas. 1	1628	2,3	3,4	1839	4,8	4,1
Pas. 2	1893	3	3,6	2143	3,5	2,3
Pas. 3	2077	2,1	3,4	2410	2,4	2,9
Pas. 4	2633	1,7	2	1429	2,8	3,4
Pas. 5	2200	3,4	2,9	2280	4,1	3,3
Pas. 6	2209	1,5	2,5	2216	2,4	2,5
Pas. 7	2367	3,1	3,3	2324	2,4	2,7
Pas. 8	2081	4,4	3,5	1882	2,7	3,3
Pas. 9	1941	2,1	2,3	1922	1,1	2,4
Pas. 10	2146	1,2	2,1	1771	0,8	1,7
Pas. 11	1655	1,5	1,8	1785	2,1	2,5
Pas. 12	1646	2,7	3,6	1431	3,5	5
Pas. 13	1378	3,4	3,7	1494	4,4	5,2
Pas. 14	3024	2,5	2,6	2211	2,8	2,9
Pas. 15	2793	2,4	3	1916	1,5	2
Pas. 16	2202	2,4	2,5	2528	2	2,4
Pas. 17	2456	3,9	5,1	1670	3,8	4,9
Pas. 18	1981	2,2	3	1635	2,2	2,7
Pas. 19	1787	2,3	4,2	1773	2,4	4
Pas. 20						
Pas. 21	2256	3,1	3,6	2429	3,7	4
Pas. 22	2072	3,2	3,2	2193	3,7	2,5
Pas. 23	2634	4,1	3,7	2285	3,1	3,6
Pas. 24	2695	2,3	3,4	2340	3,1	2,2
Pas. 25	2171	2,8	3,1	2204	2,4	2
Pas. 26	1933	2,5	3,1	1672	2,1	2,4
Pas. 27	1969	2,8	3,8	2008	2,3	3,5
Pas. 28	1679	4,2	4	1703	2,8	3,1
Pas. 29	2278	2,8	3	1985	2,5	2,7
Pas. 30	2193	2,2	2,9	2422	2,5	2,9

Appendix 4, figure 2: Overview from results after measurements on dental casts regarding hypothesis 11.