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Abnormal tooth size and morphology in subjects with cleft lip and/or palate in the north of England

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SUMMARY The aim of this study was to investigate tooth size and morphology in subjects with unilateral cleft palate (UCLP), bilateral cleft palate (BCLP), and isolated cleft palate (ICP) living in the north of England and to compare these with a control group. The measurements were undertaken retrospectively using dental study casts. To assess tooth size, the mesiodistal and buccolingual dimensions of each fully erupted permanent tooth were measured using digital Vernier callipers. The following morphological features of the teeth were assessed: upper incisor shovelling and crown form, the presence of Carabelli's tubercle on the upper molars, molar cusp number, and lower molar fissure pattern. Multilevel regression analysis was used to determine differences in tooth size, while chi-square tests and analysis of variance were used to assess differences in tooth morphology between the groups.

Tooth size was reduced in all cleft groups in both jaws, with the smallest teeth being found in the ICP group. Upper lateral incisors on the cleft-affected side in UCLP and BCLP patients showed the greatest reduction in size. The upper central and lateral incisors on the cleft-affected side in the UCLP and BCLP groups were frequently hypoplastic or peg-shaped. Molar morphology in all the cleft groups was similar to that in the control group. Reduced tooth dimensions were found in both jaws in subjects with all types of clefts, suggesting a shared genetic basis. Additionally, the upper incisors were abnormal in morphology in UCLP and BCLP subjects with or without a cleft palate, suggesting shared local aetiological factors.

Introduction

Clefts involving the lip and/or palate are common craniofacial abnormalities, accounting worldwide for around 15 per cent of all congenital malformations (Shapira *et al.*, 1999). In the United Kingdom, the incidence of a cleft lip and/or palate is approximately 1:700 live births (Clinical Standards Advisory Group, 1998).

Two main types of cleft are recognized, distinguishable from each other on both a genetic and embryological basis (Fraser, 1970). A cleft lip, with or without a cleft palate, may be either unilateral (UCLP) or bilateral (BCLP), while an isolated cleft palate (ICP) involves only the secondary palate.

Dental abnormalities are a common finding in subjects with clefts. Abnormal tooth size and abnormal tooth morphology are two of the most prevalent (Ranta, 1986). Reduced tooth size in both the mesiodistal and buccolingual dimensions has been reported in subjects with UCLP and BCLP (Foster and Lavelle, 1971; Werner and Harris, 1989), although tooth size in ICP has been found to be essentially normal (Peterka and Mullerova, 1983). Upper lateral incisors with abnormal morphology have been reported in up to 94 per cent of subjects with a cleft lip, with or without a cleft palate, on the cleft-affected side (Ranta, 1986). Abnormal morphology of the upper central incisor on the cleft-affected side has also been reported (Dewinter *et al.*, 2003). In ICP subjects, teeth with an abnormal morphology are less common, with one study finding peg-shaped lateral incisors in only 10 per cent of subjects (Heliövaara *et al.*, 2004).

Several studies have reported on tooth size abnormalities in subjects with clefts (Foster and Lavelle, 1971; Sofaer, 1979; Peterka and Mullerova, 1983; Werner and Harris, 1989). However, most of these have concentrated on only one cleft type, therefore not permitting comparison of tooth size for different cleft types within a single population. They also tend to have small sample sizes, leading to bias. Few previous studies have investigated tooth morphology in subjects with clefts. Those that have been published generally use a subjective method to assess morphology, which could be open to misinterpretation (Vichi and Franchi, 1995; Dewinter *et al.*, 2003; Ribeiro *et al.*, 2003).

The aim of the current research was to investigate the prevalence of abnormal tooth size and morphology in subjects with clefts. Subjects with UCLP, BCLP, and ICP were compared with each other and with a control group, in order to give an indication of the prevalence of dental abnormalities within different cleft groups in a single population. Objective methods were used to assess tooth morphology, increasing the repeatability of the study.

Materials and methods

Study design

This was a retrospective study using dental study casts. Ethical approval was obtained from the Central Research Ethics Committee (Ref. 05/Q0906/48). Four study groups were created: UCLP, BCLP, ICP, and controls. All

measurements were undertaken by one operator (SCW) in order to reduce error.

Identification of subjects

Subjects with clefts living in the north of England were identified from the Northern and Yorkshire Cleft Service database. Age-matched control subjects were selected from a population of patients who were about to undergo orthodontic treatment, in the same region.

Power calculation

A power calculation was carried out, based on the variable of upper central incisor mesiodistal width, as measured in a pilot study. This variable was chosen because the upper central incisor was the tooth most frequently measured, being present and fully erupted in almost all subjects. In order for the study to have an 80 per cent power to detect a 0.3 mm difference in tooth size between the groups, at a significance level of $P < 0.05$, each group needed to contain 100 subjects.

It was not possible to recruit 100 subjects into the BCLP and ICP groups. Despite this, the study had an 80 per cent power to detect a 0.45 mm difference in tooth size.

Inclusion criteria

1. Aged between 8 and 30 years at the start of the study
2. White northern European origin
3. Absence of any previously diagnosed syndrome or other craniofacial abnormality
4. Dental study casts available taken prior to extraction of any permanent teeth or of any orthodontic treatment
5. Presence of a bony cleft, whether complete or incomplete, in subjects with clefts
6. Control subjects not related to an individual with a cleft

Assessment of tooth size

All fully erupted permanent teeth were measured to the nearest 0.1 mm using digital Vernier callipers. The maximal mesiodistal and buccolingual dimensions were recorded for each tooth using the method proposed by Moorrees and Reed (1964; Figure 1). If a supplemental tooth was present, the larger of the two teeth was measured.

Assessment of morphology

The Arizona State University (ASU) Dental Anthropology System (Turner *et al.*, 1991) was used to assess the morphological features of the teeth. This system requires a series of plaster templates to score the extent of key morphological features of teeth and has been shown to be valid and reproducible (Irish, 1997). A score of 0–7 is awarded to each tooth assessed depending on the extent to which it displays a particular characteristic. Teeth which score 2 or more for a particular morphological trait are considered to positively exhibit that trait (Irish, 1997).

Upper incisor morphology was assessed using the ASU incisor shovelling template to assess the presence of incisor shovelling (Figure 2). Additionally, the number of upper incisors exhibiting a hypoplastic or peg-shaped crown form was recorded.

Molar morphology was assessed using the ASU Carabelli's tubercle template to assess the presence of Carabelli's tubercle on upper molars (Figure 3). Lower molar fissure pattern, as described by Hillson (1996), was recorded as x, y or + shaped (Figure 4). Molar cusp number was also recorded for the upper and lower molars.

Exclusion criteria

Teeth were excluded from assessment if they fell into one of the following categories:

1. Maximal bulbosity of the crown not visible;
2. Restorations extending onto the mesiodistal or buccolingual surface;

Figure 1 Measuring teeth with digital Vernier callipers.

Figure 2 The Arizona State University Dental Anthropology System template for assessing incisor shovelling.

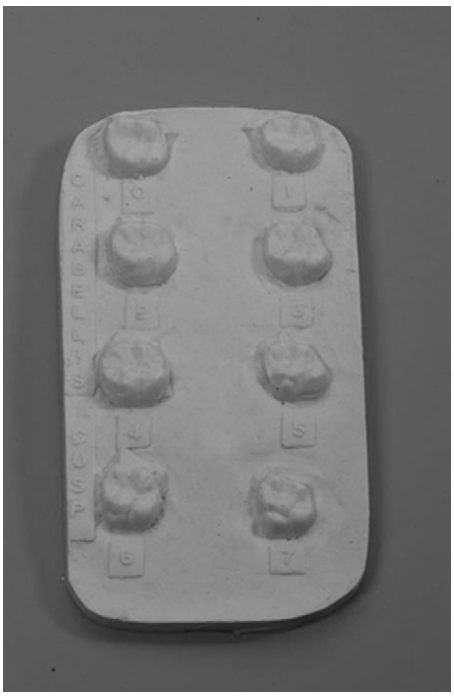

Figure 3 The Arizona State University Dental Anthropology System template for assessing the presence of Carabelli's tubercle.

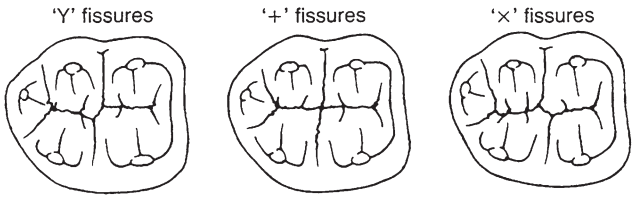

Figure 4 Lower molar fissure pattern (adapted from Hillson S 1996 Dental Anthropology and reproduced with the permission of Cambridge University Press).

3. Traumatized or severely worn teeth
4. Severely displaced or crowded teeth
5. Teeth damaged or not fully recorded on study models

Statistical analysis

Intra-operator error was determined by carrying out a pilot study. The records of 10 subjects about to undergo orthodontic treatment and 10 subjects with clefts were selected. All tooth measurements and all morphological features were assessed on two occasions at least 2 weeks apart. The variance ratio for tooth size measurements was calculated to determine if the teeth were reliably measured by the operator. Kappa tests were used to determine whether tooth morphology was reliably assessed by the operator.

Multilevel regression analysis was used to determine whether there was any significant difference between groups in terms of tooth size. This analysis was required to remove the possible influence of random effects which may have been introduced because more than one measurement was taken on each tooth.

Several different methods were used to assess tooth morphology, each requiring a different statistical test to determine if there was any significant difference between the groups. For the ASU traits of incisor shovelling and Carabelli's tubercle, a chi-square test was used as there were two categories: positive or negative. For lower molar fissure pattern, a cross-tabulated chi-square test was used, as there were three categories: x, y or +. One-way analysis of variance was used to assess the differences in molar cusp number in each group.

Results

A total of 312 subjects fulfilled the inclusion criteria for the study. The distribution of subjects, the mean ages, and the gender ratios in each group are shown in Table 1.

Operator reliability

The variance ratio in tooth size measurements was 30 and the absolute difference between measurements taken on two separate occasions was 0.25 mm. This was considered to be a good level of reliability.

A kappa score of 1.0 was recorded for the reliability of assessment of incisor shovelling. For the assessment of the remaining morphological features of the teeth, all kappa scores were greater than 0.7, indicating a good level of reliability.

Tooth size

In all four groups, the teeth were on average 0.2 mm larger in males than in females. This was statistically significant ($P < 0.05$), but was felt to be clinically insignificant. Data for male and female subjects were therefore pooled.

Tables 2 and 3 give the mesiodistal and buccolingual diameters for each tooth type in the maxilla and the mandible. Figure 5a–d show these measurements graphically.

Table 1 Distribution of male (M) and female (F) subjects between the groups.

Group	Number of subjects in group	Mean age of subjects (years/months)	Age range (years/months)	Gender distribution
Controls	100	13.5	8.11–20.2	33 M 67 F
Unilateral clefts	100	12.10	8.0–30.1	59 M 44 F
Bilateral clefts	49	12.5	8.0–28.6	33 M 17 F
Cleft palates	63	12.9	8.10–27.9	32 M 39 F

Table 2 Mesiodistal measurements [mean and standard deviation (SD)] for each tooth in each group.

Tooth notation	Controls		Unilateral clefts		Bilateral clefts		Cleft palate	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
17	10.4	0.9	10.4	0.9	10.0	0.7	10.0	0.7
16	11.3	0.7	11.1	0.7	10.9	0.6	11.1	0.7
15	7.1	0.5	6.8	0.4	6.9	0.5	6.7	0.8
14	7.2	0.4	7.0	0.4	7.1	0.3	7.0	0.7
13	8.0	0.5	7.9	0.5	7.8	0.5	7.8	0.5
12	7.0	0.6	6.5	0.9	5.7	1.1	6.6	0.7
11	8.8	0.5	8.5	0.6	8.4	0.6	8.5	0.6
21	8.7	0.5	8.4	0.6	8.3	0.7	8.4	0.5
22	7.0	0.6	6.0	0.8	5.9	0.8	6.5	0.7
23	7.9	0.5	7.7	0.5	7.7	0.5	7.7	0.4
24	7.2	0.4	7.0	0.5	7.1	0.7	7.0	0.6
25	7.0	0.5	6.8	0.4	6.8	0.6	6.9	0.8
26	11.4	0.7	11.1	0.7	11.0	0.7	11.0	0.9
27	10.7	0.9	10.6	0.8	10.1	0.5	10.3	0.6
37	10.6	0.7	10.3	0.5	10.6	0.7	10.2	0.5
36	11.1	0.6	10.9	0.8	10.9	0.7	10.8	0.7
35	7.6	0.5	7.5	0.5	7.3	0.5	7.3	0.5
34	7.4	0.4	7.3	0.4	7.2	0.3	7.2	0.4
33	7.0	0.5	7.0	0.5	6.9	0.4	6.8	0.5
32	6.1	0.4	5.9	0.4	5.8	0.5	5.8	0.4
31	5.5	0.4	5.4	0.4	5.3	0.3	5.3	0.4
41	5.5	0.4	5.4	0.3	5.2	0.4	5.3	0.4
42	6.0	0.4	5.9	0.4	5.8	0.4	5.8	0.5
43	6.9	0.4	6.9	0.5	6.8	0.5	6.7	0.5
44	7.3	0.4	7.2	0.4	7.2	0.3	7.2	0.4
45	7.5	0.5	7.4	0.5	7.3	0.5	7.3	0.4
46	11.0	0.7	11.0	0.7	10.9	0.7	10.7	0.9
47	10.5	0.5	10.7	0.5	10.7	0.6	10.5	0.6

Table 3 Buccolingual measurements [mean and standard deviation (SD)] for each tooth in each group.

Tooth notation	Controls		Unilateral clefts		Bilateral clefts		Cleft palates	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
17	10.9	0.6	10.8	0.8	11.3	0.8	10.6	0.8
16	11.1	0.6	10.9	0.6	11.0	0.5	10.9	0.7
15	9.4	0.6	9.4	0.5	9.1	0.5	9.2	0.5
14	9.1	0.5	9.3	0.5	9.0	0.5	8.8	0.7
13	8.1	0.6	7.8	0.7	7.5	0.5	7.7	0.7
12	6.3	0.6	5.9	0.8	5.0	1.1	6.2	0.8
11	7.0	0.6	6.6	0.8	6.4	0.8	6.7	0.7
21	7.0	0.6	6.5	0.8	6.1	0.8	6.7	0.7
22	6.3	0.7	5.5	0.9	5.1	0.7	6.0	0.7
23	7.9	0.6	7.6	0.6	7.5	0.8	7.7	0.7
24	9.2	0.5	9.2	0.7	8.8	0.7	8.7	0.8
25	9.4	0.6	9.3	0.7	9.2	0.5	8.9	1.0
26	11.2	0.5	11.0	0.7	11.0	0.6	10.9	0.7
27	10.9	0.6	11.0	0.9	11.2	0.6	10.8	0.8
37	10.1	0.7	10.1	0.7	10.3	0.6	9.9	0.5
36	10.4	0.6	10.3	0.7	10.2	0.5	10.2	0.6
35	8.5	0.6	8.6	0.6	8.4	0.3	8.3	0.6
34	7.9	0.5	7.9	0.5	7.8	0.5	7.7	0.5
33	7.3	0.7	7.2	0.7	7.0	0.7	7.0	0.6
32	6.4	0.6	6.0	0.7	5.8	0.7	5.9	0.6
31	6.1	0.5	5.8	0.6	5.8	0.6	5.7	0.6
41	6.1	0.5	5.8	0.6	5.8	0.6	5.7	0.6
42	6.3	0.6	6.0	0.7	5.8	0.6	5.9	0.7
43	7.2	0.7	7.2	0.6	7.0	0.8	6.9	0.7
44	8.0	0.5	8.1	0.5	7.8	0.6	7.9	0.6
45	8.6	0.6	8.7	0.5	8.3	0.6	8.5	0.6
46	10.7	0.5	10.4	0.7	10.4	0.6	10.3	0.6
47	10.3	0.7	10.2	0.7	10.5	0.6	10.1	0.6

The teeth in the control group were, in general, larger for both mesiodistal and buccolingual dimensions than those in any of the three cleft groups, with the ICP group tending to have the smallest teeth.

In the UCLP group, the teeth were on average 0.3 mm smaller in the maxilla and 0.2 mm smaller in the mandible than those in the control group, for both mesiodistal and buccolingual dimensions. The smallest tooth in this group was the upper lateral incisor, which, when present, was on average 0.7 mm smaller for both dimensions than the upper lateral incisor in the control group. This was statistically significant ($P < 0.001$). Pairs of teeth on the left and right side of the jaws were compared to determine whether there was any asymmetry in size. The upper central and lateral incisors on the cleft-affected side, when present, were found to be significantly smaller in both dimensions than those on the unaffected side ($P < 0.001$). There was no asymmetry for any other pairs of teeth.

In the BCLP group, the teeth were, on average 0.5 mm smaller in the maxilla and 0.3 mm smaller in the mandible than those in the control group, in both mesiodistal and buccolingual dimensions. Once again, when present, the upper lateral incisor was the smallest tooth, being on average 1.2 mm smaller in both mesiodistal and buccolingual dimensions than the upper lateral incisor in the control group. This was statistically significant ($P < 0.001$).

In the ICP group, the teeth were on average 0.3 mm smaller in the mesiodistal dimension and 0.4 mm smaller in the buccolingual dimension compared with those in the control group. All teeth in both jaws were affected to an equal degree. All teeth were significantly smaller than those in the control group ($P < 0.05$).

Tooth morphology

Tooth morphology data for male and female subjects were pooled, as previous studies have shown that morphological features of the teeth do not exhibit sexual dimorphism (Turner *et al.*, 1991).

Table 4 summarizes the data for morphological features of the upper incisors. The proportions of upper incisors exhibiting shovelling or abnormal morphology are given as percentages of the total number of incisors present in each group. The upper lateral incisor was commonly missing in subjects with a cleft lip, with or without a cleft palate, being absent in 27.8 per cent of UCLP subjects and in 45.8 per cent of BCLP subjects. Incisor shovelling was a relatively uncommon

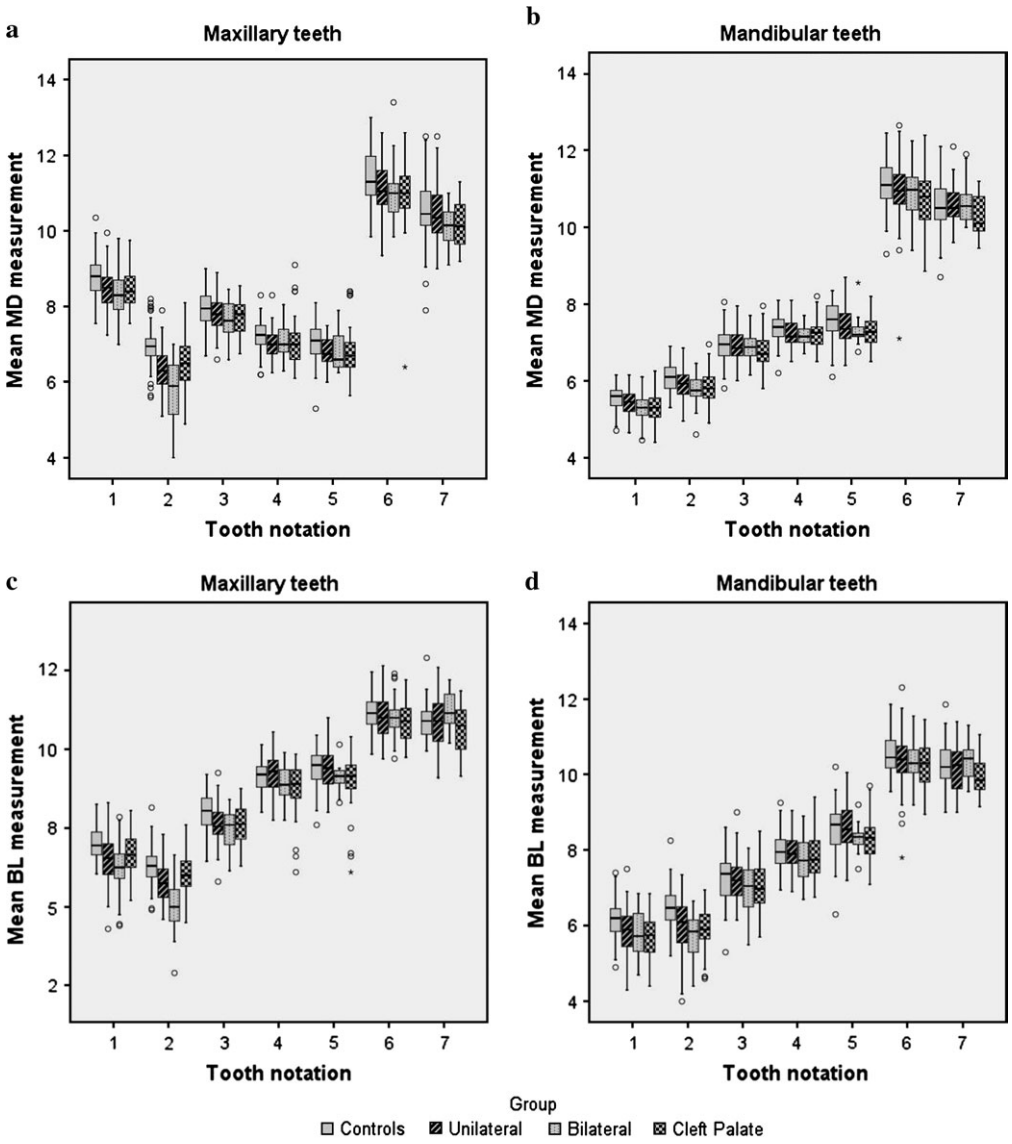

Figure 5 Mesiodistal (a and b) and buccolingual (c and d) measurements for each tooth in the maxillar and mandible in the four groups investigated.

finding in all four groups. However, in the UCLP and BCLP groups, the upper lateral incisor was significantly more likely to exhibit shovelling than the upper lateral incisor in the control group ($P < 0.05$). In the BCLP group, the upper central incisor was also significantly more likely to exhibit shovelling than the upper lateral incisor in the control group ($P < 0.001$). The upper central and lateral incisors in both the UCLP and BCLP groups were statistically significantly more likely to exhibit shovelling than those in the control or ICP groups ($P < 0.001$). Abnormal (hypoplastic or peg-shaped) upper incisors were not found in any subject in the control or ICP group. In the BCLP group, the upper central and lateral incisors were abnormal in 20.7 and 34.4 per cent of subjects, respectively. In the UCLP group, the upper lateral incisor was abnormal in 18.2 per cent of subjects. When the cleft-affected and unaffected sides were compared in subjects with UCLP, the upper lateral incisor was found to be abnormal on the cleft-affected side in 60.0 per cent of subjects and on the unaffected side in 6.2 per cent of subjects. This was statistically significant ($P < 0.05$).

The data for morphological features of the upper and lower molars are summarized in Tables 5 and 6, respectively. Carabelli's tubercle was a more common finding on upper first than upper second molars in all four groups. There was no significant difference between any of the groups in terms of the proportion of subjects exhibiting a Carabelli's tubercle. In the control, UCLP and BCLP groups, the most common lower first molar fissure pattern was y-shaped. In the ICP group it was + shaped. The difference in the proportion of subjects with each fissure pattern observed between the ICP group and the other three groups was significant ($P < 0.05$). No significant differences were

observed between the groups in terms of the number of cusps.

Discussion

The current study is thought to be the largest to date to investigate tooth size and morphology in subjects with clefts and addresses some of the problems identified in previous studies. A power calculation was undertaken and a large sample of subjects with different types of clefts was drawn from the same population. Valid and reproducible methods were used to evaluate tooth morphology and powerful statistical analysis was used to analyse the results. However, the current study could have been improved further. Due to difficulties in locating the records of subjects who were suitable for inclusion into the study, it was not possible to recruit as many subjects as had been hoped into the BCLP and ICP groups. Despite this, large numbers of subjects were recruited into all four groups and the power of the study was not significantly affected. Due to the large number of subjects required, it was not possible to obtain random samples or to gender match the groups. These factors and also the retrospective methodology used in this study could have introduced bias.

Tooth size

Teeth in all three cleft group were smaller than those in the control group, in both mesiodistal and buccolingual dimensions. These findings are similar to those of Foster and Lavelle (1971) and Werner and Harris (1989). However, the fact that the smallest teeth were, in general, found in the ICP group was unexpected. Previous studies have shown that teeth in subjects with ICP are essentially the same size as those in control subjects (Peterka and Mullerova, 1983). The difference noted in the current study may be due to the powerful statistical analysis used.

The actual difference in tooth size between subjects with clefts and controls, although statistically significant, was on average less than 0.5 mm. A reduction in tooth size of less than 0.5 mm was considered clinically insignificant. However, in the UCLP and BCLP groups, the upper lateral incisor was clinically significantly smaller than in the control group. Asymmetry in the size of the upper central and lateral incisors on the cleft-affected side versus the unaffected side was also noted in subjects with UCLP, with the incisors on the cleft-affected side being smaller than those on the unaffected side. Similar findings have been reported by Sofaer (1979).

The results show a clear difference between the two genetically and embryologically distinct cleft types. Where the cleft involves the alveolus, local aetiological factors related to the clefting process appear to have a direct local effect on the adjacent developing odontogenic epithelium, as the central and lateral incisors on the cleft-affected side were reduced in size to a much greater degree than any of the other teeth.

A small reduction in size was seen for all teeth, in both jaws, in all three cleft groups, when compared with the control group. This may point to an underlying genetic link between clefting and tooth size. The smallest teeth were

Table 4 Morphological features of the upper incisors.

	Percentage of erupted incisors positive for shovelling	Percentage of incisors with abnormal morphology
Upper central incisor		
Controls	5.1	0
Unilateral clefts	3.6	0
Bilateral clefts	12.8	20.7
Isolated cleft palates	0	0
Upper lateral incisor		
Controls	5.9	0
Unilateral clefts	13.7	18.2
Bilateral clefts	24.3	34.4
Isolated cleft palates	5.9	0

Table 5 Morphological features of the upper first molars.

	Cusp number, mean (SD)	Positive for Carabelli's tubercle (%)
Controls	4.1 (0.3)	48.4
Unilateral clefts	4.4 (0.5)	39
Bilateral clefts	4.2 (0.5)	34.8
Isolated cleft palates	4.3 (0.4)	46.7

Table 6 Morphological features of the lower first molars.

	Cusp number, mean (SD)	Y-shaped fissure pattern (percentage)	X-shaped fissure pattern (percentage)	+-shaped fissure pattern (percentage)
Controls	4.7 (0.5)	69.8	4.3	26.1
Unilateral clefts	4.6 (0.5)	52.2	8.2	40.0
Bilateral clefts	4.7 (0.4)	63.3	3.8	32.9
Isolated cleft palates	4.6 (0.5)	47.1	5.9	48.0

found in the ICP group, indicating that the genetic link is strongest in this type of cleft.

Tooth morphology

It was hypothesized that the clefting process may have a greater effect on the morphology of teeth adjacent to the cleft than on those distant from the cleft. In order to investigate this, the morphology of teeth adjacent to and distant from the cleft was studied. The upper incisors were chosen as these teeth are adjacent to the alveolar cleft in subjects with a cleft lip, with or without cleft palate. The first molars were selected as they were distant from the cleft and because, with the exception of the incisors, they were the only teeth to be fully erupted in all subjects included in the study.

It is not possible, from the results of the current research, to make a judgement as to whether tooth morphology for other teeth is abnormal in subjects with clefts. An investigation into the morphology of other teeth in subjects with clefts is planned.

The current study is thought to be the first to use the ASU classification to determine morphological features of teeth in subjects with clefts. This classification was chosen because it allows key morphological features of the teeth to be assessed objectively rather than subjectively. For the upper incisors, shovelling is the key morphological feature most commonly studied using the ASU classification and the presence of Carabelli's tubercle for the upper first molars. These morphological features were therefore chosen for investigation in the current study.

Bailey (2000) reported that in the general population of the UK, incisor shovelling is relatively uncommon, with 13.1 per cent of upper central incisors being positive for the presence of shovelling. Upper incisor shovelling is known to have a genetic basis and is seen more frequently in primitive populations (Hillson, 1996). In the current study, it was hypothesized that there may be a genetic link between clefting and the presence of incisor shovelling, with the underlying genetics of the clefting process causing the upper incisors to revert to a more primitive form.

Shovelling of the upper incisors was a significantly more common finding in the UCLP and BCLP groups in the current study when compared with the ICP and control groups. These results may support the hypothesis of a genetic link between clefting and incisor shovelling, or it may be that local aetiological factors involved in the formation of the cleft have a direct effect on the morphology of the adjacent developing tooth germs. As there was no increase in incisor shovelling in the ICP group, the second hypothesis seems more likely.

Abnormal (hypoplastic or peg-shaped) upper central and lateral incisors were found frequently in the UCLP and BCLP groups, but not in the ICP or control groups. These results indicate that there is likely to be a direct local effect on the developing tooth germs where the cleft involves the alveolus, rather than a genetic effect. The results are supported by several studies in which abnormal upper incisor morphology was found in subjects with a cleft lip, with or without a cleft palate (Ranta, 1986; Vichi and Franchi, 1995; Dewinter *et al.*, 2003; Ribeiro *et al.*, 2003).

Bailey (2000) observed that in the UK general population, 60 per cent of upper first molars are positive for the presence of Carabelli's tubercle. In the current study, it was hypothesized that if tooth size was abnormal in subjects with clefts, this may be accompanied by an alteration in cusp number. Carabelli's tubercle is an accessory molar cusp, and it was therefore hypothesized that this feature would be seen more or less frequently in subjects with clefts.

The current study is thought to be the first to investigate molar morphology in subjects with clefts. No significant difference in molar morphology was found between any of the groups, including the numbers that were positive for the presence of Carabelli's tubercle. It can therefore be concluded that there is no link between clefting and the morphology of teeth distant from the site of the cleft.

There does not appear to be any genetic link between clefting and tooth morphology, as only those teeth adjacent to the cleft, in subjects where the cleft involved the alveolus exhibited abnormal morphology. It seems more likely that local aetiological factors involved in the clefting process have a direct effect on the adjacent odontogenic epithelium, thereby affecting the morphology of adjacent teeth.

Conclusions

1. In all subjects with clefts, the teeth were statistically smaller in both the mesiodistal and buccolingual dimensions than those in a control group. Subjects with ICP had the smallest teeth.
2. In subjects with a cleft lip, with or without a cleft palate, the upper incisors on the cleft-affected side were statistically smaller than those on the unaffected side and were reduced in size to a much greater degree than any of the other teeth. In ICP, all the teeth in both jaws were similarly reduced in size.
3. In subjects with a cleft lip, with or without a cleft palate, upper incisor morphology on the cleft-affected side was frequently abnormal.
4. There was no relationship between clefting and molar morphology.

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