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Survey of congenitally missing teeth in orthodontic patients in Eastern Bavaria

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SUMMARY This retrospective study examined the occurrence of congenitally missing permanent teeth and the need for dental treatment in the Regensburg University Medical Centre of Eastern Bavaria. Using a dental administration software tool, a total of 1442 patients who presented for orthodontic treatment between 1994 and 2006 were identified. After exclusion of 89 patients with incomplete records, 1353 subjects (635 males and 718 females) remained for analysis. Of these, 1130 had no missing permanent teeth, 52 had cleft lips, 110 had one to two teeth missing, 34 had three to five missing teeth, and 27 had greater than or equal to six missing teeth. The analyses focused on the type and number of missing teeth and on differences in the severity of dental agenesis according to gender and to referrals from various geographic regions around Regensburg. The data were statistically analysed using two-tailed tests.

The following teeth were most frequently missing: tooth 35 (5.9 per cent), 45 (5.1 per cent), 22 (4.0 per cent), 12 (3.6 per cent), 15 (3.1 per cent), and 25 (3.0 per cent). No statistically significant difference in gender was found for one to two missing permanent teeth (low degree), hypo- or oligodontia (severe degree), or cleft lip. The odds ratio (OR) of presenting with hypo- or oligodontia compared with no missing teeth was higher among subjects originating from geographic regions outside Regensburg than from those from Regensburg, and it was statistically significantly higher for patients from Passau {OR = 3.53 [95% confidence interval (CI) = 1.18–10.52]} and Landshut [OR = 3.65 (95% CI = 1.22–10.99)]. The high prevalence and severe degree of dental agenesis of permanent teeth found in these groups of patients likely reflects distinct referral patterns for patients originating from geographic regions outside Regensburg. These data reinforce the need for a specialized dental treatment centre with the capacity to adequately serve a large rural area in Eastern Bavaria.

Introduction

Dental agenesis is an important clinical and public health problem ((Muller *et al.*, 1970; Nunn *et al.*, 2003; Murdock *et al.*, 2005; Weingärtner *et al.*, 2007). Patients with missing permanent teeth may suffer from a reduced chewing ability, inarticulate pronunciation, and an unfavourable aesthetic appearance (Proff *et al.*, 2008). This potentially affects their self-esteem, communication behaviour, and professional performance (Kleck and Strenta, 1980). In addition to the importance of functional and aesthetic considerations, a major therapeutic challenge is the need to perform treatment in the growing young patient (Behr *et al.*, 2008). Independent of the number of missing permanent teeth and the cause of the condition, treatment of dental agenesis should be initiated during adolescence. Ideally, interim treatment should take place even before these children realize that they are different from other children (Kleck and Strenta, 1980; Nunn *et al.*, 2003; Behr *et al.*, 2008), i.e. around 7–9 years of age. The treatment of patients with dental agenesis represents an interdisciplinary challenge, that includes specialists in oral surgery, operative dentistry, orthodontics, and prosthodontics (Lowry *et al.*, 1966, Behr *et al.*, 2008; Morsczeck *et al.*, 2008). Adding further complexity, dental agenesis of the permanent teeth is frequently associated with syndromes, such as ectodermal dysplasia or Down syndrome (Book, 1950; Lowry *et al.*, 1966; Freire-Maia and Pinheiro 1984; Pinheiro and Freire-Maia, 1994).

Treatment of subjects with dental agenesis is comprehensive and costly. Murdock *et al.* (2005) estimated that the costs of comprehensive interdisciplinary treatment exceeded €40 000 per patient. Even in mild cases with only one to two missing permanent teeth, minor prosthodontic intervention such as a fixed partial denture costs between €2000 and €10 000 per patient. Such treatment has a marked financial impact on families. As a consequence, financial

assistance programmes and adequate treatment facility centres need to be established for patients with dental agenesis.

Data regarding the prevalence of congenitally missing permanent teeth are available from Scandinavia (Egermark-Eriksson and Lind, 1971; Wisth *et al.*, 1974), the UK (Brook, 1974), Switzerland (Bachmann, 1974), and North America (Castaldi *et al.*, 1966; Polder *et al.*, 2004). These data show that the prevalence of congenitally missing permanent teeth in the general population ranges from 4 to 7 per cent. The studies are summarized in Table 1.

The aim of the current research was to investigate the occurrence of congenitally missing permanent teeth in orthodontic patients referred to the Regensburg University Medical Centre, which serves a mainly rural population of 2.2 million inhabitants of Eastern Bavaria, Germany. It was hypothesized that the frequency of missing teeth according to site and gender corresponds to known frequencies from the published literature (Polder *et al.*, 2004) and that patients with severe forms of agenesis from rural areas in Eastern Bavaria have a greater likelihood of being referred to the medical centre than their counterparts originating from Regensburg. In more remote and countryside areas, genetic populations may exist, which have a higher incidence of disabilities (Polder *et al.*, 2004).

Materials and methods

Study design

This study is a retrospective case series analysis and includes all patients who presented for orthodontic treatment at Regensburg University Medical Centre between 1994 and 2006. Patients with incomplete records (n = 89) were excluded.

A dental administration software tool (Report Smith search tool of HighDent Plus, Koblenz, Germany) was used to identify 1442 orthodontic patients in the hospital database. The primary data consisted of the patient's medical history, the clinical dental status, gypsum models of the maxilla and mandible, and a dental pantomograph. The analyses focused on the type and number of missing teeth, the average number of missing teeth per patient, unilateral versus bilateral agenesis, and differences in dental agenesis according to gender and referrals from various geographic regions. Table 2 lists the variables considered.

Patients with more than three teeth missing were aggregated into a subgroup termed 'severe tooth agenesis' and were compared with those without missing teeth. In addition, the subgroup of patients with severe tooth agenesis from outside Regensburg was compared with the corresponding group of patients from Regensburg. Patients with only one or two missing teeth were considered to have a low-grade dental agenesis. Odds ratios (ORs) and confidence intervals (CIs) were calculated using two-by-two tables. These statistics are commonly used in these types of studies (Feinstein, 1985; Jenicek, 1995).

The level of statistical significance was set at $P < 0.05$, two tailed. All analyses were performed using the Statistical Package for Social Science 15.0 (SPSS Inc., Chicago, Illinois, USA).

Results

Patient characteristics

The final data set comprised 1353 Caucasian patients: 1130 had no missing permanent teeth, 52 had cleft lips, 110 had one to two missing teeth, 34 had three to five missing teeth, and 27 had greater than or equal to six missing teeth. Gender distribution is shown in Figure 1.

The mean age at initial presentation for treatment was 13.6 years (SD, 6 years and range, 5–44 years). Only two patients were younger than 7 years of age, thus the probability of a false-positive diagnosis of missing teeth due to tooth buds with a late onset of mineralization was negligible, and both cases were included in the analyses.

Approximately one-fifth of the patients lived in Regensburg (258, 19 per cent), the majority came from

Table 1 Previous studies on the prevalence of dental agenesis in various populations, percentage of subjects with one or more agenetic teeth. Selected studies that fulfilled the inclusion criteria of the meta-analysis of the prevalence of dental agenesis of permanent teeth (Polder *et al.*, 2004).

Author (year)	Country	Sample size	Population	Percentage of prevalence of dental agenesis
Glenn (1964)	USA	777	Dental clinic	5.1
Castaldi *et al.* (1966)	Canada	457	Dental clinic	4.2
Davies (1968)	Australia	2170	School children ages 12-14 years, Australian White	6.3
Egermark-Eriksson and Lind (1971)	Sweden	3327	School children aged 10–16 years	6.3
Bachmann (1974)	Switzerland	8694	School children aged 9–10 years, European White	7.7
Brook (1974)	UK	1115	School children aged 11–14 years, European White	4.4
Thompson and Popovich (1974)	Canada	1191	School children aged 6–12 years	7.4
Wisth *et al.* (1974)	Norway	813	School children aged 9 years	6.8
Al Emran (1990)	Saudi Arabia	500	Arab aged 13–14 years	4.0

Table 2 Listing of the investigated variables.

Investigated variable	Subgroup
Present age	
Age at diagnosis	>7 years
Place of residence	Zip code 93 Regensburg (urban area)
	Zip code 93 Regensburg (rural areas)
	Zip code 94 Passau
	Zip code 92 Amberg
	Zip code 84 Landshut
	Others
Type of dental agenesis	No missing permanent teeth
	1–2 missing permanent teeth
	Hypodontia < 6 missing teeth
	Oligodontia ≥ 6 missing teeth
Syndromes	No syndrome
	Ectodermal dysplasia
	Cleft lip
	Goldenhar syndrome
	Apert syndrome
	Down syndrome
	Others
Type of missing teeth	11–17, 21–27, 31–37, 41–47
Location	Mandible
	Maxilla
Gender	Female
	Male

adjacent rural areas (615, 45.5 per cent), and the remaining patients were referred from Passau (162, 12 per cent), Landshut (148, 10.9 per cent), Amberg (114, 8.4 per cent), and other smaller towns (<50 000 residents) in eastern Bavaria (56, 4.2 per cent).

Medical syndromes were diagnosed in only a very few patients: ectodermal dysplasia (n = 4), Down syndrome (n = 3), Goldenhar syndrome (n = 1), and Apert syndrome (n = 1).

Missing teeth

Missing permanent teeth were found in 171 (12.6 per cent) of the 1353 patients. Among these, 64.3 per cent had one or two missing teeth, three to five teeth were absent in 19.9 per cent, and oligodontia was found in 15.8 per cent. Absence of one to two permanent teeth or a severe degree of absence (three to five or greater than or equal to six missing teeth) was equally distributed between the females and males. The most frequently missing teeth were 35 (5.9 per cent), 45 (5.1 per cent), 22 (4.0 per cent), 12 (3.6 per cent), 15 (3.1 per cent), and 25 (3.0 per cent). Table 3 shows the frequency of the site and the number of missing teeth.

The OR of presenting with severe forms of missing teeth (agenesis) was higher among patients from regions outside Regensburg and was statistically significantly greater in patients referred from Passau [OR = 3.53 (1.18–10.52)] and Landshut [OR = 3.65 (1.22–10.99)].

Discussion

The data for this retrospective study was based on residents of eastern Bavaria seeking orthodontic treatment at the Regensburg University Medical Centre. Generally, no data are available that represent the dental status of the entire adolescent population of eastern Bavaria at 7–18 years. Although orthodontic facilities are available in private dental practices, subjects who require multidisciplinary treatment are most frequently referred to the University of Regensburg. Therefore, no bias was expected in the group of patients with severe agenesis or those with a syndrome. A bias may be possible in the group with only one to two missing permanent teeth because treatment of this group does not require a highly sophisticated treatment protocol, as for those with severe forms of missing teeth (Behr *et al.*,

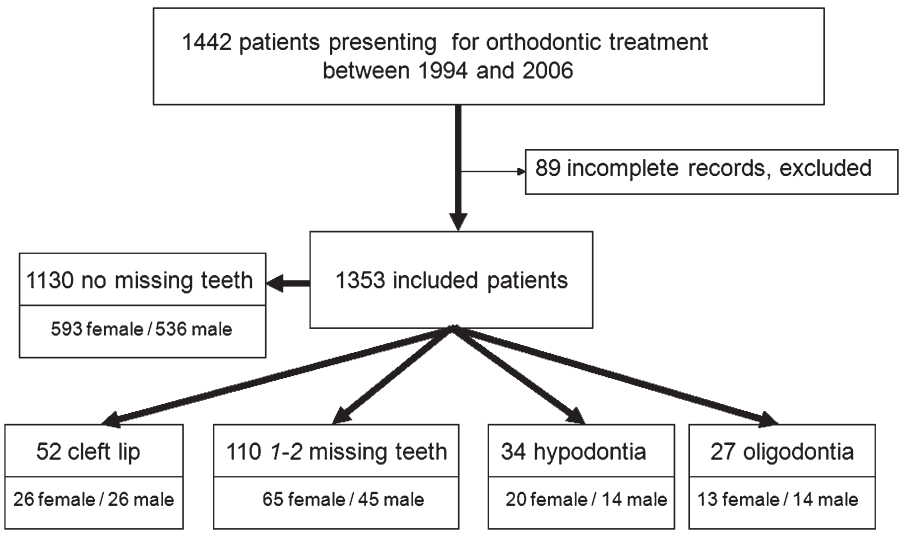

Figure 1 Flow chart showing the number and distribution of patients included or excluded from the current study.

Table 3 Number and distribution of dental agenesis of permanent teeth found in 1353 patients presenting at Regensburg University Medical Centre between 1994 and 2006.

Type of tooth	Number of missing teeth	Percentage of missing teeth
Tooth 11	1	0.1
Tooth 12	49	3.6
Tooth 13	12	0.9
Tooth 14	12	0.9
Tooth 15	42	3.1
Tooth 16	5	0.4
Tooth 17	9	0.7
Tooth 21	2	0.1
Tooth 22	54	4.0
Tooth 23	16	1.2
Tooth 24	18	1.3
Tooth 25	40	3.0
Tooth 26	3	0.2
Tooth 27	12	0.9
Tooth 31	17	1.3
Tooth 32	13	1.0
Tooth 33	5	0.4
Tooth 34	14	1.0
Tooth 35	80	5.9
Tooth 36	3	0.2
Tooth 37	10	0.7
Tooth 41	20	1.5
Tooth 42	12	0.9
Tooth 43	9	0.7
Tooth 44	12	0.9
Tooth 45	69	5.1
Tooth 46	5	0.4
Tooth 47	16	1.2
Total	693	100

2008). The percentage of undetected cases with one to two missing permanent teeth may be higher. The aim of this study was, however, to investigate the prevalence of severe forms of agenesis in the countryside of eastern Bavaria and to compare the results with those from Regensburg city and the literature (Polder *et al.*, 2004).

In this investigation of congenitally missing permanent teeth among orthodontic patients, it was found that the frequency of missing teeth according to site and gender corresponded to known population frequencies of dental agenesis (Polder *et al.*, 2004). In addition, the data suggest that patients with severe forms of agenesis from rural areas of Eastern Bavaria have a greater likelihood of being referred than their counterparts originating from Regensburg. Specifically, the ORs of severe forms (in comparison to patients without missing teeth) were up to three times higher in those from outside Regensburg as compared with patients from Regensburg. This can be interpreted as reflecting referral patterns for patients with more severe forms of dental agenesis from rural geographic areas served by the medical centre. By comparison, private practices in rural areas are suitably equipped to treat relatively minor cases of dental agenesis. In these cases, for example, a three-unit fixed partial denture can easily be used close the gap, if one to two teeth are missing (Behr *et al.*, 2008).

Population prevalences of dental agenesis reported in the literature typically range between 4 and 7 per cent (Glenn, 1964; Castaldi *et al.*, 1966; Davies, 1968; Egermark-Eriksson and Lind, 1971; Bachmann, 1974; Brook, 1974; Thompson and Popovich, 1974; Wisth *et al.*, 1974; Al Emran, 1990). Because the data in the present study are based on patients presenting with severe forms of dental agenesis at Regensburg University Medical Centre, the figures are not comparable with population-based prevalences. However, it was possible to quantify the occurrence of missing permanent teeth seen at a tertiary care centre over a decade, the relative frequencies of its various forms, and the frequencies relative to other orthodontic conditions and according to the region of residence in Eastern Bavaria. A high prevalence was also found in the neighbouring area of Switzerland, which has a comparable climate and environment. The present study cannot explain why some of countryside of East Bavaria showed a higher prevalence of dental agenesis in comparison with the meta-analysis of Polder *et al.* (2004) or the data of Regensburg city. The reason for dental agenesis is unknown, but mutations of the genes PAX9 and MSX1, which are inherited in an autosomal dominant manner, have been suggested (Stockton *et al*., 2000; Frazier-Bowers *et al.*, 2002).

Conclusion

The prevalence of congenitally missing permanent teeth in the population of the countryside of eastern Bavaria was higher than in the city of Regensburg and also for that reported for northern Europe. Multidisciplinary treatment facilities for patients with dental agenesis should, therefore, be available in the centre of East Bavaria. There is a need for a population-based epidemiological study that would enable a determination of the occurrence and possible geographic variation of permanent missing teeth in this region.

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