The long-term effect of a preventive programme on caries, periodontal disease and tooth mortality in individuals with Down syndrome

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Abstract

Introduction: Individuals with Down syndrome (DS) have an increased prevalence of periodontal disease compared with otherwise normal, age-matched control groups and other intellectually disabled patients of similar age distribution. Caries prevalence tends to be lower in this population.

Aim and objectives: To determine the long-term effect of periodic plaque control, on the progression of periodontal diseases and tooth mortality in patients with DS.

Material and Methods: 25 adolescents and adults with DS (12 females/13 males, mean age 35.6 ± 8.6 years) were chosen to participate in the study from all patients with a disability, who had been treated for dental problems in a private dental practice in Borken, Germany. Standard indices to assess dental caries (DMFT), periodontal disease (PSR; bone loss; age ratio; tooth loss) were applied. Routine dental care and preventive care were performed over at least ten years.

Results: Patient Group I consisted of 10 patients aged ≤ 15 years; Group II 15 patients aged ≥ 16 years, on first attendance. The overall mean DMFT score of all surveyed patients with Down syndrome was 13.4. For Group I and Group II, the mean DMFT scores were 8 and 17, respectively. Across all sites, 49.3% exhibited calculus and bleeding on probing. Shallow pockets and deep pocketing could be identified in 37.5% and 13.2% of all sites, respectively; 58.3% of all patients had slight bone loss in relation to age and 25% of all patients exhibited advanced bone loss. During the observation period an average of 2.5 teeth were lost in all patients, 0.5 in Group I and 3.8 in Group II.

Conclusions: The results indicate that well-performed preventive procedures can prevent the progression of periodontal destruction in patients with DS. Only a few sites exhibited signs of advanced attachment loss and only few teeth were lost over the years of maintenance.

Key words: Long-term effect, preventive programme, caries, periodontal disease, tooth mortality, Down syndrome

Introduction

Down syndrome (DS) is an autosomal chromosomal anomaly and the most commonly known single cause of mental retardation (Hennequin et al., 1999). It occurs approximately once in 600-1,000 births (Desai, 1997). Genetically, Down syndrome is a gene dosage disease with an over-expression of genes located on the distal half of the long arm of chromosome 21, known as band 21q22 (Neibuh, 1974; Hennequin et al., 1999; Fiske and Shafik 2001).

The phenotype of the syndrome is characterised by mental retardation, weak muscle tone, and typical orofacial features with epicanthic folds at the eyelids, a broad bridge of the nose, an underdeveloped mid-part of the face in relation to an oversized mandible with protrusive dentition, an open mouth and an oversized, fissured tongue. DS patients are susceptible to infections because of genetic abnormalities in their immune system.

Individuals with DS have an increased prevalence of periodontal disease compared with otherwise normal, age-matched control groups and other intellectually disabled patients of similar age distribution (Barnett et al., 1986; Reuland-Bosma and van Dijk, 1986; Modéer et al., 1990; Ulseth et al., 1991; Barr-Agholme et al., 1998). Reuland-Bosma and van Dijk (1986) have reported that the same amount of plaque accumulation gives rise to earlier, more rapid and more extensive gingival inflammation in DS children compared to non-disabled, children.

Signs of alveolar bone loss can be detected in a high percentage of younger patients with DS. A previous study was able to verify a distinct increase in the level of periodontal disease in the age group of 25-29 year-old subjects (Franz,
2002). The aetiology and pathogenesis of periodontal diseases in patients with DS are not fully understood. The exaggerated immune-inflammatory response of the tissues cannot be explained by poor oral hygiene alone and might be the result of an impaired cell-mediated and humoral immunity (Saxén and Aula, 1982; Izumi et al., 1989; Sohoel et al., 1992; Sohoel et al., 1995a; Sohoel et al., 1995b; Barr-Agholme et al., 1998).

Because of the altered inflammatory host response to bacterial challenge and the patient’s inability to self-perform adequate oral hygiene, the prognosis for periodontal treatment in patients with DS is questionable in the majority of cases (Hanookai, 2000; Cichon et al., 2001). While the aim of periodontal therapy is to regain periodontal health, the objective of preventive programmes is the preservation of gingival and periodontal health. Although the benefit of frequent preventive care in patients with DS has been demonstrated (Sakellari et al., 2001; Yoshihara et al., 2005), no programmes on the long-term effect of periodic plaque control, on the progression of periodontal diseases and tooth mortality in patients with DS, have been reported.

The present study presents the caries prevalence, periodontal status and tooth loss in a group of children, adolescents and young adults with DS after at least a decade of preventive and curative care.

Materials and methods

Subjects
Twenty-five adolescents and adults with DS were chosen to participate in the study from all patients with a disability, who had been treated for dental problems in a private dental practice in Borken, Germany. The criteria for inclusion were attending the practice for at least 10 years and preventive care regularly undertaken at least two to four times a year.

Study design
The entire group (n=25) was divided into two patient cohorts according to the age when the patients attended for the first time in the practice for dental care. Patient Group I consisted of 10 patients aged ≤ 15 years and patient Group II consisted of 15 patients who were aged ≥ 16 years when they first attended the preventive programme.

Clinical examinations
The following variables were recorded on all available teeth with the exception of third molars:

Caries detection and DMFT
Clinical, radiographic and recurrent caries lesions were identified according to criteria from the World Health Organisation (1997). Each tooth was recorded as healthy, decayed or filled (DF) or missing (M) in order to estimate the DMFT index (Klein and Palmer, 1940). Because of the young age of patients at the beginning of treatment, the calculation of the DMFT index was limited to the last examination.

Restorative Index (RI)
The Restorative Index expresses the patient’s treatment needs. It is calculated by the portion of decayed and filled teeth that have been treated restoratively (F/(D+F)x100).

Periodontal Screening and Recording (PSR)
The mouth was divided into sextants and coded according to the recommendations of the Periodontal Screening and Recording procedure (American Dental Association and American Academy of Periodontology, 1992). The Periodontal Screening and Recording system is a modification of the CPITN Index. It was officially introduced in 1993 and recommended by the American Academy of Periodontology (AAP) and the American Dental Association (ADA) as a quick and reliable system for the early detection of periodontal disease.

The WHO Periodontal Examination Probe was used throughout this study (World Health Organisation, 1978). It is a specially designed lightweight probe with a 0.5mm ball tip and a black band between 3.5 and 5.5mm. The ball tip enhances detection of sub-gingival calculus or overhanging margins. The coloured band facilitates rapid interpretation of probe depths. The Periodontal Screening and Recording (PSR) codes are based on the following system:

- Code 0 - Coloured area of the probe remains completely visible in the deepest crevice in the sextant. No calculus or defective margins are detected. Gingival tissues are healthy with no bleeding after gentle probing.
- Code 1 - Coloured area of the probe remains completely visible at the deepest probing depth in the sextant. No calculus or margins are detected. There is bleeding after gentle probing.
- Code 2 - Coloured area of the probe remains completely visible at the deepest probing depth in the sextant. Supra- or sub-gingival calculus and/or defective margins are detected.
- Code 3 - Coloured area of the probe remains partly visible at the deepest probing depth in the sextant.
- Code 4 - Coloured area of the probe completely disappears, indicating that the probing depth is greater than 5.5mm.

Bone loss/ age ratio (BL/Age)
For patients characterised as cooperative, a panoramic radiograph was exposed, and for partly cooperative patients, intraoral radiographs were taken with the parallel technique, under general anaesthesia.

Alveolar bone loss was assessed in the posterior tooth region at the site with the most advanced periodontal attachment loss using a calliper. In adolescents and young adults,
radiographic bone loss was defined as the distance from the cemento-enamel junction (CEJ) to the alveolar crest (AC) exceeding 2mm (Aass et al., 1994; Bishop et al., 1995). The percentage of bone loss was calculated by transforming the alveolar bone loss in relation to the radiographic tooth length. The bone loss/age ratio (BL/age) was determined by dividing the percentage of bone loss by the age of the patient. The risk categories for further attachment loss were subdivided into six intervals from 0.25 to ≥ 1.5. The threshold for the moderate risk category was 0.5 and for the high risk category 1 (Lang and Tonetti, 2003).

Number of lost teeth

The mean number and annual rates for those teeth which had been extracted during the entire period of observation were calculated.

Treatment

Following the baseline examination, all carious lesions were treated and faulty restorations adjusted. Teeth with a questionable prognosis or those which could not be successfully treated were extracted.

Preventive programme

In addition to clinical examinations, the preventive sessions included an instruction in proper personal oral hygiene, professional tooth cleaning and dental treatment, whenever it was indicated.

Subsequent to the initial examination, patients with a disability, their relatives and/or guardians received detailed information about the role of dental plaque and nutrition in the aetiology of dental caries and periodontitis, on an individual basis. They were instructed how to perform oral hygiene correctly. A method of tooth cleaning was recommended for each individual patient which could be carried out by the patient or their relatives and/or their caregiver. The patient’s oral hygiene technique was checked and, if necessary, corrected. Following motivation and instruction, a professional tooth cleaning programme was carried out (Axelsson, 1994). The teeth were carefully scaled, plaque and dental calculus were removed and all teeth were polished at baseline in one session. The vestibular and lingual surfaces of all teeth were cleaned with the aid of a rotating rubber cup. A rotating, pointed bristle brush was used to clean the occlusal fissures.

In addition, a 0.2% chlorhexidine solution was administered in a spray form (Chlorhexamed® Forte 0.2 % Spray, GlaxoSmithKline, Germany) twice a day for one week after professional tooth cleaning (Francetti et al., 2000) in some patients with compromised oral hygiene, due to the impossibility of performing adequate mechanical oral hygiene measures. Subsequent to the termination of the baseline examination, prevention and treatment period, all patients were recalled four times per year for evaluation of their oral health and hygiene status, re-instruction in tooth cleaning and for dental therapy, whenever it was necessary.

On average, 48 % (n=12) of the patients appeared twice, 40% (n=10) 3 times and 12% (n=3) 4 times a year to the follow-up sessions (Figure 1).

Statistical analysis

A frequency distribution for the DMFT, PSR, maximum PSR and BL/Age scores was calculated for the last clinical and radiographic examinations. The median value, mean value with standard deviation, the minimum, maximum and quartiles 1 and 3 for lost teeth during the observation period were determined for both age groups. Tooth mortality between the two age groups was compared using the Mann-Whitney U-test.

Figure 1a–e. A 2-year-old patient with DS who attended for preventive care regularly from the time of eruption of the first primary tooth

Results

Of the 25 subjects selected, 12 were females and 13 males, with a mean age ± SD, 35.6 ± 8.6 years. For the two groups, those < 15 years at first presentation in the practice (Group I) and those ≥ 16 years at first presentation (Group II), the mean age (± SD) of the patients in Group I was 7 ± 3.9 years and 24.5 ± 5.3 years in Group II, respectively at the initial visit (Table 1 and Figure 2).
At the time of the last observation, the mean age (± SD) of the patients in Group I was 27.3 ± 6 years and 41.1 ± 4.9 years in Group II, respectively (Table 2 and Figure 3). The mean duration (± SD) of the observation period was 17.8 ± 4.7 years for the entire group, 20.4 ± 3.6 years for Group I and 16 ± 4.5 years for Group II (Table 3 and Figure 4).

Twelve patients were living at home, 13 were in institutions or communities that provide for the needs of persons with an intellectual impairment. With regard to the level of cooperation, in order to accept the clinical and radiographic examinations as well as the preventive care programme, 15 patients were identified as sufficiently cooperative for their clinical examinations and professional tooth cleaning to be carried out in the conscious state. Ten patients were partly cooperative: radiographs of their teeth could be exposed but only under general anaesthesia.

Figure 2 Mean DMFT, decayed teeth (DT), missing teeth (MT), filled teeth (FT) scores at the last observation

![Figure 2: Mean DMFT, decayed teeth (DT), missing teeth (MT), filled teeth (FT) scores at the last observation](image)

<table>
<thead>
<tr>
<th>Table 1 Age of subjects at the initial visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age ≤ 15 years at the initial visit to practice (n = 10)</td>
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<tr>
<td>--------------------------------------------</td>
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<tr>
<td>Age (years)</td>
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<tr>
<td>Median</td>
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<td>Min - Max</td>
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</table>

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<thead>
<tr>
<th>Table 2 Age of subjects at the time of the last observation</th>
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<tbody>
<tr>
<td>Age at the initial visit to practice ≤ 15 years (n = 10)</td>
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<tr>
<td>-----------------------------------------------------------</td>
</tr>
<tr>
<td>Age (years)</td>
</tr>
<tr>
<td>Median</td>
</tr>
<tr>
<td>Min - Max</td>
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</tbody>
</table>
Figure 3 Frequency distribution of PSR codes at the last examination

Table 3 Period of observation

<table>
<thead>
<tr>
<th></th>
<th>Age ≤ 15 years at the initial visit to practice (n = 10)</th>
<th>Age ≥16 years at the initial visit to practice (n = 15)</th>
<th>Entire Group (n = 25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age ± SD</td>
<td>20.4 ± 3.8</td>
<td>16 ± 4.7</td>
<td>17.8 ± 4.8</td>
</tr>
<tr>
<td>Median</td>
<td>22</td>
<td>17</td>
<td>20</td>
</tr>
<tr>
<td>Min - Max</td>
<td>12 – 24</td>
<td>10 - 21</td>
<td>10 - 24</td>
</tr>
</tbody>
</table>

Figure 4 Frequency distribution of BL/Age categories at the clinical examination
Table 4 Mean DMFT, decayed teeth (DT), missing teeth (MT), filled teeth (FT) scores for the total patient group at the last observation (n = 25)

<table>
<thead>
<tr>
<th></th>
<th>DT</th>
<th>MT</th>
<th>FT</th>
<th>DMFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean ± SD</td>
<td>0.5 ± 1.3</td>
<td>7.1 ± 6</td>
<td>5.7 ± 6.1</td>
<td>13.3 ± 9.7</td>
</tr>
<tr>
<td>Median</td>
<td>0</td>
<td>5</td>
<td>3</td>
<td>14</td>
</tr>
<tr>
<td>Min-Max</td>
<td>0 – 6</td>
<td>0 – 28</td>
<td>0 – 18</td>
<td>1 – 28</td>
</tr>
</tbody>
</table>

Table 5 Mean DMFT, decayed teeth (DT), missing teeth (MT), filled teeth (FT) scores for the age group ≤15 years at the last observation (n = 10)

<table>
<thead>
<tr>
<th></th>
<th>DT</th>
<th>MT</th>
<th>FT</th>
<th>DMFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean ± SD</td>
<td>0.9 ± 1.9</td>
<td>3.4 ± 2</td>
<td>3.6 ± 5</td>
<td>8 ± 7.3</td>
</tr>
<tr>
<td>Median</td>
<td>0</td>
<td>4</td>
<td>0.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Min-Max</td>
<td>0 – 6</td>
<td>0 – 6</td>
<td>0 – 12</td>
<td>1 – 12</td>
</tr>
</tbody>
</table>

Table 6 Mean DMFT, decayed teeth (DT), missing teeth (MT), filled teeth (FT) scores for the age group ≥16 years at the last observation (n = 15)

<table>
<thead>
<tr>
<th></th>
<th>DT</th>
<th>MT</th>
<th>FT</th>
<th>DMFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean ± SD</td>
<td>0.3 ± 0.7</td>
<td>9.5 ± 8.2</td>
<td>7.1 ± 6.4</td>
<td>17 ± 9.6</td>
</tr>
<tr>
<td>Median</td>
<td>0</td>
<td>8</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>Min-Max</td>
<td>0 – 2</td>
<td>0 – 28</td>
<td>0 – 18</td>
<td>1 – 28</td>
</tr>
</tbody>
</table>

Figure 5 Mean DMFT scores and single components at the last observation
Caries (DMFT)
The mean DMFT scores and the single D, M and F components at the last examination are presented in Tables 4-6 and Figure 5. The overall mean DMFT score of all surveyed patients with Down syndrome was 13.4. For the age Group I and Group II, the mean DMFT scores were 8 and 17, respectively. In Group I, the filling component (FT: 3.6) dominated the scores whereas in the second group the missing teeth (MT: 9.6) represented the highest scores.

Remaining teeth at the last observation
Table 7 and Figure 6 present the number of remaining teeth in the two age groups at the last examination. The average number of teeth present at the last observation was 20.8 for all patients and 24.5 and 18.4 for the Groups I and II, respectively.

Restorative Index (RI)
The mean restorative index was 91.9% for all patients combined. In the first age group the RI was 80% and in the second group the RI amounted to 95.9%.

Periodontal Screening and Recording (PSR)
The frequency distribution of the PSR codes for the two age groups are presented in Figure 7; 49.3% of all sites exhibited calculus and bleeding on probing. Shallow pockets and deep pocketing could be identified in 37.5% and 13.2% of all sites, respectively. In age Group I, 88.3% of the sites had gingivitis and calculus (code 2) and 11.7% of the sites had shallow pockets (code 3). In the second age group, calculus and gingivitis could be detected in 18.4% of sites. In the second group, 57.9% of sites had shallow pockets and 23.7% of sites exhibited deep pockets (code 4).

Periodontal Screening and Recording (PSR) – maximal codes
The frequency distribution of the maximal PSR codes is presented in Table 8. It shows that no patient examined was disease-free. In this study, 29.2% of all subjects with DS exhibited calculus and bleeding, 50% had shallow and 20.8% deep pockets. In the first patient group 70% of the subjects with DS exhibited calculus and gingivitis and 30% shallow pockets. In the second age group 64% of the patients had shallow pockets and 36% deep pockets.

Bone loss/age ratio (BL/Age)
The bar chart in Figure 8 illustrates the distribution of sites with the most advanced periodontal bone loss in relation to the patient’s age at the last examination. It shows that 58.3% of all patients had slight bone loss in relation to the age (BL/Age: 0.25) and 25% of all patients exhibited advanced bone loss (BL/Age: 1.25 and BL/Age: ≥ 1.5).

In the first age group, 90% of patients exhibited the lowest risk category (BL/Age: 0.25) and 10% of DS subjects of this age group showed the highest risk category (BL/Age: ≥ 1.5) for further attachment loss. In the second group, 35.7% of the patients had low bone loss (BL/Age: 0.25), 28.6% had moderate bone loss (BL/Age: 0.75) in relation to the age and 25% were at high risk for further attachment loss with a BL/Age relation of 1.25 and ≥1.5.

Number of lost teeth
During the observation period an average number of 2.5 teeth were lost in all patients, 0.5 in Group I and 3.8 in Group II (Table 9 and Figure 9). Twenty incisors, 13 canines, 13 premolars and 14 molars were lost to caries (16) and advanced periodontal disease (36).

The calculated annual rates of tooth loss/patient for the entire observation period were 0.14 teeth for all DS subjects, 0.02 teeth in age Group I and 0.24 teeth in the second age group. Because of the small number of lost teeth, statistically significant differences between the two independent age groups could not be determined.

Table 7 Number of remaining teeth at the last examination

<table>
<thead>
<tr>
<th></th>
<th>Age ≤ 15 years at the initial visit to practice (n = 10)</th>
<th>Age ≥16 years at the initial visit to practice (n = 15)</th>
<th>Entire Group (n = 25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age ± SD</td>
<td>24.5 ± 2</td>
<td>18.4 ± 8.5</td>
<td>20.8 ± 7.3</td>
</tr>
<tr>
<td>Median</td>
<td>24</td>
<td>20</td>
<td>23</td>
</tr>
<tr>
<td>Min - Max</td>
<td>22 – 28</td>
<td>1 - 28</td>
<td>1 - 28</td>
</tr>
</tbody>
</table>
**Figure 6** Remaining teeth at the last examination

**Figure 7** Frequency distribution of PSR codes at the last examination

**Table 8** Frequency distribution of maximum PSR codes

<table>
<thead>
<tr>
<th></th>
<th>Code 0</th>
<th>Code 1</th>
<th>Code 2</th>
<th>Code 3</th>
<th>Code 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entire Group (n = 25)</td>
<td>0</td>
<td>0</td>
<td>29.2</td>
<td>50</td>
<td>20.8</td>
</tr>
<tr>
<td>Age at the initial visit to practice</td>
<td>0</td>
<td>0</td>
<td>70</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>Age at the initial visit to practice</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>64</td>
<td>36</td>
</tr>
</tbody>
</table>
Figure 8 Frequency distribution of BL/Age categories at the clinical examination

Table 9 Number of lost teeth

<table>
<thead>
<tr>
<th></th>
<th>Age ≤ 15 years at the initial visit to practice (n = 10)</th>
<th>Age ≥16 years at the initial visit to practice (n = 15)</th>
<th>Entire Group (n = 25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>5</td>
<td>57*</td>
<td>62</td>
</tr>
<tr>
<td>Mean age ± SD</td>
<td>0.5 ± 1.5</td>
<td>3.8 ± 3.9</td>
<td>2.5 ± 3.7</td>
</tr>
<tr>
<td>Median</td>
<td>0</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Min - Max</td>
<td>0-4</td>
<td>0-13</td>
<td>0-13</td>
</tr>
</tbody>
</table>

*Mann-Whitney U- test.: *P > 0.05*

Figure 9 Lost teeth during the period of observation
The present study presents the long term outcome of a regularly performed preventive dental treatment in a group of subjects with Down syndrome over a period of \( \geq 10 \) years. In order to compare the results with the findings of other studies it should be noted that all dental examinations, preventive and treatment efforts were carried out in one private dental practice during normal office hours.

Caries (DMFT)

At the final clinical observation, the caries experience in the patients’ groups exhibited an overall mean DMFT score of 13.4 with a mean DT score of 0.5; 80\% (n = 20) of all patients had no carious lesions. The caries experience in DS patients in this study demonstrated a lower mean DMFT value and a lower mean DT score than those of age-matched patients with and without disabilities in Germany (Cichon and Donay, 2004; Micheelis and Schiffner, 2006) (Table 10). These findings are consistent with findings of most studies on the oral health status of patients with Down syndrome, which show similar caries experience compared to population groups without disabilities (Bradley and McAlister, 2004; Lee et al., 2004; Cheng et al., 2007). The low rate of caries in the current study, especially in the first age group, cannot be explained solely by the generally low caries rates in patients with DS but may be as a consequence of the regularly performed preventive care with professional tooth cleaning, repeated oral hygiene demonstrations as well as early detection and consequent treatment of carious lesions as well as the daily use of a fluoridated dentifrice.

Remaining teeth at the last observation

The mean number of 20.8 remaining teeth for all patients at the final observation visit is in accordance with the results of a previous study on the dental status of patients with disabilities (Cichon and Donay, 2004). In the latter study, the authors found an average number of 21.1 teeth present in age-matched patients groups. Comparing the low mean number of remaining teeth in the second age group with the number of remaining teeth in the non-disabled population, it may be that subjects with Down syndrome have more congenitally missing teeth than people in the general population (Steinbicker et al., 1972; Acerbi et al., 2001).

Restorative Index (RI)

The provision of dental restorations in DS subjects in this study is slightly lower in comparison with the mean RI value in the 35-44 year age group of the Fourth German Oral Health Study (Micheelis and Schiffner, 2006) but markedly higher than the level of restorations in age-matched patients with disabilities in Germany (Cichon and Donay, 2004) (Table 10).

Periodontal Screening and Recording (PSR)

The frequency distribution of the PSR codes in the two age groups shows that all sites were in need of varying amounts of periodontal therapy (codes 2, 3 and 4). In 86.8\% of all sites there was evidence of calculus and bleeding on probing or shallow pockets (code 2 and 3). Deep pockets could only be detected in 13.2\% of sites. While gingivitis could be detected in 88.3\% of all sites in the first age group, 81.6\% of the sites in the second age group had shallow or deep pockets (code 3 and 4).

The distribution of the maximal PSR codes in the current study shows a higher portion of DS patients with calculus and bleeding than in the population without disabilities, whereas the percentage of shallow and deep pockets was in accordance with the results of the Fourth German Oral Health Study of 2006 (Micheelis and Schiffner, 2006).

Bone loss/age ratio (BL/Age)

With regard to the distribution of all DS patients with moderate (58.3\%) and severe bone loss (25\%), these findings are in contrast to the results of a former study on the prevalence and severity of periodontal diseases in adults without disabilities (Hugoson and Laurell, 2000). Although these authors established that about 80\% of the population had one or more sites with bone loss of 10\%, only very few individuals, about 5\%, exhibited a mean bone loss of 2mm or more.

On the other hand, Saxen et al. (1977), Barr-Agholme et al. (1992) and Scott (1998) reported that advanced bone loss in patients with Down syndrome could be

<table>
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<th>DT</th>
<th>MT</th>
<th>FT</th>
<th>DMFT</th>
<th>RI</th>
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<tr>
<td>Disabilities</td>
<td>4.3</td>
<td>6.9</td>
<td>5</td>
<td>16.2</td>
<td>53.8%</td>
</tr>
<tr>
<td>(2004)</td>
<td></td>
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<tr>
<td>German Oral</td>
<td>0.5</td>
<td>2.4</td>
<td>11.7</td>
<td>14.5</td>
<td>95.9%</td>
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<tr>
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</tr>
<tr>
<td>Min-Max</td>
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<td>0 - 28</td>
<td>0 - 18</td>
<td>1 – 28</td>
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detected more frequently than has been indicated in this study.

**Tooth mortality**
The tooth mortality during the period of observation, with a mean value of 2.5 teeth for all patients and an average of 0.5 teeth for the first age group of this study, is lower than the findings of other studies in intellectually impaired adults (Gabre et al., 1999, 2000). Only the loss of a mean of 3.8 teeth in the second age group concurs with the findings of these studies in which an average loss of 3.7 teeth over a period of 10 years has been reported.

The low value for the mean tooth mortality/subject in the first age group (0.5 teeth/subject) during the observation period is in agreement with the findings of long-term studies on the oral health status of individuals without disabilities. Over a 12-year interval, a mean of 0.4 teeth/subject (Wennström et al., 1993) and, over a 30-year period, means of 0.4, 0.7 and 1.8 teeth/subject were lost in different age cohorts (Axelsson et al., 2004). The annual tooth loss of 0.14 teeth/subject corresponds to the results of long-term studies (McFall, 1982; Goldman 1986) in well maintained patients, in which a mean annual loss of 0.14 teeth/subject and 0.16 teeth/subject, respectively has been reported.

The distribution of tooth mortality amongst individual patients showed a cumulative tooth loss in a small group of patients. In five patients, 69% (n = 43) of teeth had to be extracted, while in 12 patients no teeth were lost. According to the definition by Hirschfeld & Wasserman (1978), 17 patients were classified as ‘well maintained’ (loss of 0 – 3 teeth) seven belonged to the ‘down hill’ group (loss of 4-9 teeth), and one was assigned to the ‘extreme downhill’ group (loss of 10 or more teeth).

**Conclusions**
The caries experience with a low mean DMFT values and DT scores, as well as the high level of the restorative index compared with age-matched patients with and without disabilities in Germany demonstrates that caries is not a specific problem in DS patients. On the basis of regularly performed preventive care, including professional tooth cleaning with instruction in oral hygiene procedures and the early detection and treatment of carious lesions, destruction of the dentition by caries could be prevented.

The combination of impaired host-response mechanisms and inadequate oral hygiene has an unfavourable impact on the progression and treatment of gingivitis and periodontitis in DS subjects. The high percentage of patients and sites with calculus and gingival inflammation in the present study shows that professional tooth cleaning without careful supportive home oral care had only a minor effect on the accumulation of bacterial plaque and gingival inflammation. Although in some studies the effectiveness of surgical and non-surgical periodontal treatment in DS subjects could be demonstrated (Sakellari et al., 2001; Zaldivar-Chiapa et al., 2005; Cheng et al., 2008) it has to be noted that the results of these studies were obtained under clinical trials conditions. The patients were seen for professional tooth cleaning at least every 4-6 weeks. The entire observation period was limited to a maximum of one year.

The removal of supragingival plaque alone leads to reduced subgingival bacterial counts (Loos et al., 1988; McNabb et al., 1992; Hellstrom et al., 1996; Westfelt et al., 1998; Ximenez-Fyvie et al., 2000; Haffajee et al., 2001; Petersilka et al., 2002; Teles et al., 2006) especially at sites with shallow pocket depths (McNabb et al., 1992; Westfelt et al., 1998). In previous studies, the authors of the current study, were able to demonstrate that a single, supragingival plaque removal visit had no beneficial effect on the accumulation of supragingival plaque and gingivitis in DS subjects but led to a significant decrease in the total number of microorganisms in the subgingival plaque, for a period of 3 months (Cichon et al., 1998; Cichon et al., 2001). The results of the current study indicate that well-performed preventive procedures can prevent the progression of periodontal destruction in patients with DS. Only a few sites exhibited signs of advanced attachment loss and only a few teeth were lost over the years of maintenance.

The progression of periodontal diseases in people with Down syndrome seems to be age-related (Izumi et al., 1989; Franz, 2002). The clinical benefit of plaque control measures in DS subjects depends on the period of life when it is initiated. The earlier in childhood that dental care commences, the better is the periodontal status in adulthood.

Patients with DS who had been introduced to the preventive programme at ≤ 15 years of age had sites with calculus and bleeding on probing only, at the final clinical observation and only a few sites with probing depths and advanced bone loss. Two patients in this age group lost a total of five teeth. Most patients with DS in the second age group, who attended the preventive care programme for the first time at an age of ≥ 16 years, had more sites with pockets and a markedly higher number of lost teeth than the patients in the younger age group.

This does not imply that the introduction of preventive programmes is of no benefit in older patients with Down syndrome. The low number of sites with deep pockets and bone loss and the relative low tooth mortality in the present study show that severe periodontal destruction could also be prevented in older patients with DS.

The results of the current and former studies demonstrate that the accumulation of bacterial plaque and gingivitis seem to be unavoidable in subjects with DS and that periodontal diseases in DS subjects can largely be kept
under control by preventative programmes, when initiated early on.

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