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Oral health problems and their management in patients with Down Syndrome—a narrative review

Review

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Abstract

Patients with Down Syndrome (DS) commonly exhibit various anomalies in the masticatory organ and oral cavity. This paper aims to consolidate information regarding oral health challenges faced by individuals with DS, along with strategies employed for their management and care. Our review, conducted via PubMed and Scopus, spanned the period from January 1977 to December 2023. It included original research articles and comprehensive reviews focusing on both pediatric and adult populations. The paper analyzes 71 articles, categorizing them into six sections: oro-facial problems, tooth conditions, dental and skeletal age, dental caries, periodontal diseases, swallowing, masticatory muscles, salivation, behavior management, physical therapy, and early intervention. Understanding oral health issues in individuals with DS is crucial for providing tailored dental care and treatment planning. Regular dental assessments, early intervention strategies such as physiotherapy and behavioral management, and a collaborative approach involving oral health professionals, caregivers, and the individuals themselves are critical to preventing oral health issues and improving overall health and well-being in people with DS.

Keywords

Down syndrome • salivary flow • dental caries • life style • physiotherapy

1. Introduction

Down syndrome (DS) is one of the most common genetic disorders, affecting approximately 1 in every 700 births. Since its initial description in 1866 by British physician John L. Down, there have been significant advancements in our understanding and management of Down syndrome. This progress has been driven by scientific breakthroughs and evolving attitudes towards intellectual disabilities [1]. The true nature of Down syndrome was not fully comprehended until 1959 when French geneticist Jérôme Lejeune identified the aberration of chromosome 21 in affected individuals [1].

Historically, individuals with Down syndrome faced significant challenges due to limited understanding of the condition and inadequate medical care. Quality of life was often poor, with many individuals subjected to neglect and abuse. However, with advances in medical care and social awareness, it has significantly improved [2]. With early interventions and tailored support, many individuals with Down syndrome can now thrive, lead fulfilling lives, and actively contribute to their communities.

While the overall quality of life for individuals has been enhanced, they may still encounter various systemic diseases and health challenges [1,3,4]. The extra copy of chromosome 21 leads to an overexpression of the genes located on this chromosome. This gene dosage imbalance disrupts normal cellular and developmental processes [5]. Thus, DS patients are prone to congenital heart defects, leukemia, gastrointestinal and thyroid problems, and early-onset Alzheimer's disease [1,2].

Moreover, research indicates that individuals with Down syndrome frequently experience specific oral health problems [1-7].

Hence, this paper aims to summarize challenges related to oral health in children and adults with DS and the strategies used to address and manage these problems.

2. Methods

In our review, there are a total of 71 scientific articles selected and studied from the databases PubMed and Scopus, using the keywords: "Down syndrome," "salivary flow," "dental care," "dental caries," "oral health," "physiotherapy." The database was searched from 1977 to 2023. Articles are divided into six aspects, which will be discussed in more detail:

1. Oral-facial, tooth condition, dental and skeletal age
2. Dental caries
3. Periodontal diseases
4. Swallowing, masticatory muscles, salivation
5. Behavior management
6. Physical therapy and early intervention

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3. Results

3.1. Oral-facial and tooth condition, dental and skeletal age

3.1.1. Oro-facial condition

One of the apparent features observed in this disease is a relatively high vault of the hard palate (with a distinguishing V-shape) [1], resulting from hypoplasia of two-thirds of the mid-face, including maxillary bones. Additionally, the mandible tends to be in a protruding position due to incomplete oral-facial development. These structural anomalies can lead to challenges in proper swallowing, mastication, and speech [7].

Panoramic radiographs of DS patients typically show a mandibular foramen width that is relatively larger compared to that of healthy individuals of the same age. In contrast, the mandibular canal width and mandibular ramus size tend to be smaller. These variations can be attributed to alterations in facial growth seen in DS [8]. The larger mandibular foramen in individuals with DS is clinically relevant for the success of mandibular block anesthesia [8,9] and could make it easier to anesthetize a patient because it may provide a larger target area for the anesthetic injection. However, it is essential to combine this anatomical understanding with precise clinical technique [10].

Common oral manifestations in DS patients include a relatively large tongue (macroglossia), fissured or geographic tongue, and incomplete lip sealing, which can contribute to issues like drooling and mouth breathing [1,7,11].

The presence of these features can increase the risk of respiratory infections and affect oral health [3,7].

Research studies indicate that Castillo-Morales oral-facial therapy is an effective method for treating DS patients with tongue protrusion and drooling. Manual therapy has been shown to have a significant impact on changing the patient's tongue position from protruded to retruded, leading to an improvement in the drooling situation. Following the treatment, there is a notable enhancement in oral-facial function, with an increased intrinsic muscle tone of the tongue and lips, which brings them back to a more normal position [3].

3.1.2. Dental anomalies and malocclusion.

The most distinctive dental feature of DS individuals is the presence of teeth that are smaller than average [1,7,8,12]. When one or more teeth show a clear and noticeable reduction in size, the condition is considered a dental anomaly (microdontia). Microdontia of primary and permanent teeth, especially the maxillary lateral incisors, is commonly seen in DS patients [13,14]. Most DS patients also have congenitally missing teeth, which can lead to space problems [1,7]. Conversely, some DS patients may have supernumerary additional teeth [1], and crowding, particularly in the maxilla, is not uncommon [1]. Cases of taurodontism, characterized by an elongated pulp chamber, have also been reported in DS patients [1,7]. DS children may develop craniofacial characteristics similar to those of other patients with short stature of various etiologies [15-17].

Compromised general health in DS individuals predisposes them to developmental anomalies of enamel [1,18]. Contributing factors such as developmental deficiency of the maxillary bone growth and macroglossia can result in anterior open bite and Angle class III malocclusion [6,7,19].

Notwithstanding the significant impact of genetic factors on craniofacial morphology [7], the evaluation and treatment of malocclusion in DS patients remain viable. As highlighted in the review by Faulks et al. [19], both functional and conventional orthodontic treatments can be effective for DS children when coupled with appropriate behavior management techniques.

3.1.3. Dental and skeletal age

It is challenging to definitively define the trend in dental age of individuals with DS due to variations in assessment methods and the different ages of study participants.

In a study by Moraes et al., dental panoramic radiographs were used to assess the dental age of individuals with DS aged 3-16 years. The study found that dental age was delayed by less than 12 months compared to chronological age in 24.53% of males and 22.45% of females, and between 12 and 24 months in 3.78% of the males and 12.25% of the females. The majority of DS patients, including 48.28% of the males and 38.77% of the females, had a dental age that was advanced by up to 12 months [12].

Conversely, in a study by Hala et al. who used the Nolla method of panoramic radiograph assessment, dental age was underestimated for both DS children and healthy control subjects, aged between 3 and 17 years. However, this delay was more evident in DS individuals [20].

Based on the clinical examination of the presence, absence, and number of permanent teeth in DS patients aged 6-12 years, Patnaik et al. calculated that the mean delay in tooth eruption in DS was approximately 1.20 years [21].

The other study revealed that at the age of 7 years, individuals with DS typically have a skeletal age that is delayed compared to their chronological age. However, by the age of 15, their skeletal age is often advanced relative to their chronological age [22]. This finding suggests that individuals with DS experience a shorter period of adolescent development and complete bone maturation earlier than those without DS [22].

3.2. Dental caries

Poor oral hygiene, improper brushing techniques, and a high frequency of carbohydrate consumption have been noted in some DS patients [23,24]. Some authors reported decreased saliva flow in patients with DS [25-27], associated with low pH [26,28] and buffering capacity [28], although in the study by Cogulu et al. salivary flow rate, pH, and buffering capacity were similar in the DS and control groups [29]. It has been suggested

that psychosocial stress in the institutionalized individuals, who do not live with the family, decreases their saliva flow and salivary immunoglobulin levels [25] and aggravates immunodeficiency [30]. Besides, prescribed medications may cause xerostomia, which can further compromise oral hygiene in these patients [31].

Despite these challenges, individuals with DS generally have relatively low dental caries rates [7,27,31,32]. Several factors may contribute to this phenomenon, according to various studies.

The presence of congenital hypodontia and microdontia in individuals with Down syndrome may result in lower caries indices compared to healthy individuals of the same age. Additionally, spacing between teeth can lead to lower rates of interproximal caries [27,31,33].

The study by Cogulu et al. revealed that the patients with DS had significantly higher levels of salivary IgA, which resulted in lower susceptibility to dental caries [29]. Conversely, Chauschu et al. noticed that the salivary secretion rate of IgA in DS patients was 85% lower compared to the controls [25]. According to Areias et al. [27] the IgA secretion rate in Down syndrome children was 29% lower but not significantly different.

The reason for heterogeneity in the results of different studies could be the age of the participants with DS. Chauschu et al. have shown that older individuals with the syndrome have lower salivary IgA levels compared to younger individuals, due to immunodeficiency that intensifies with age [25].

Areias et al. [27] compared risk factors for dental caries in children with Down syndrome and their siblings. The results showed that children with DS had lower *Mutans streptococci* counts than their siblings, despite lower salivary flow rate. The authors concluded that the lower exposure to cariogenic microflora may contribute to the reduced caries rate in children with Down syndrome.

Although the above-mentioned studies have reported lower caries indices in individuals with DS, participants of the studies by Moreira et al. [34] and Hashizume et al. [35] had caries experiences similar to those of healthy children.

The variation in reported caries rates in children with Down syndrome can be attributed to possible differences in caregiver attitudes and practices towards maintaining oral hygiene and dietary differences, including the frequency of sugar intake, access to regular dental care, and preventive measures [36,37]. Socioeconomic factors may also influence caries rates in DS patients, with those in institutions often experiencing lower rates, possibly due to positive caregiver attitudes [33,36].

Regardless of dental caries susceptibility, early prevention is crucial for maintaining good oral health in individuals with DS. Dentists and hygienists should emphasize the importance of tooth brushing, fluoride application, fissure sealants, and dietary counseling as preventive measures to improve oral health outcomes in this population [32].

3.3. Periodontal disease

Patients with Down syndrome demonstrate an increased likelihood of developing periodontal disease at an early age [12]. Commonly observed periodontal problems in DS patients include gingivitis, prominent horizontal bone loss, advanced periodontitis, and remarkable tooth loss. The periodontium in DS patients shows higher levels of bacteria such as *Streptococcus constellatus*, *Treponema socranskii*, and *Propionibacterium acnes*, which are commonly associated with periodontal diseases [32]. Improper oral hygiene habits and inadequate dental plaque control may further deteriorate periodontal problems of DS patients [38].

The concentration of uric acid, an antioxidant that protects cells and tissues in the mouth from oxidative damage, is higher in DS patients compared to healthy individuals [30,39,40]. Elevated uric acid levels in the saliva of individuals with Down syndrome are primarily due to genetic factors, such as the overexpression of the superoxide dismutase 1 (SOD1) gene and altered purine metabolism, as well as physiological responses to increased oxidative stress [30,41,42].

Reuland-Bosma et al. have noted that DS patients are more prone to acute necrotizing ulcerative gingivitis (ANUG), which can lead to symptoms like gingival swelling, bleeding, and pain [30].

In a study by Satir, alveolar bone loss in DS patients was found to be more pronounced than in healthy individuals [8]. The most common type observed was horizontal bone loss, which tends to have an earlier onset and shows a more severe and generalized progression, often connected with a clinical attachment loss of more than 4mm [38,43,44].

The function of phagocytic cells is linked to the loss of periodontal attachment. However, the intensity of monocyte phagocytosis is identified as a more significant predictor of periodontal attachment level than the granulocyte phagocytic activity [43]. In individuals with DS, the correlation between monocyte phagocytic intensity and loss of attachment appears to be stronger than in individuals without DS. This could be due to the effect of having an extra copy of chromosome 21, which is known to encode various proteins involved in the generation of oxygen radicals [43]. High salivary levels of superoxide dismutase activity in DS patients confirm the significant impact of oxidative stress on the early onset of periodontal disease [45].

On the other hand, some DS patients exhibit lower expression of the TNFSF13B gene, which is involved in the activation and proliferation of B-cells. This reduced expression can lead to a higher susceptibility to periodontal disease due to immune and inflammatory deregulation [46].

The high incidence of type 1 diabetes mellitus and immunosuppression in DS patients [47] can lead to oral candidiasis [27]. DS individuals with oral candidiasis often show impaired antibody opsonization, which reduces phagocyte

function and makes them more susceptible to bacterial and fungal infections [30]. Prophylaxis and preventative oral hygiene management are essential for DS patients. The use of mouth rinses with chlorhexidine gluconate and regular dental check-ups can help maintain their oral health [1,48].

Individuals with Down syndrome who have congenital heart defects may need prophylactic antibiotics before certain dental procedures. This precaution is to prevent infective endocarditis. This decision should be guided by current medical guidelines and tailored to the specific needs of the patient in consultation with their healthcare providers. It is crucial to assess the type of congenital heart defect and the nature of the dental procedure to determine the appropriate use of antibiotics [49,50].

3.4. Swallowing, masticatory muscles, salivation

Electromyography (EMG) examinations reveal that activation of the masticatory muscles in DS patients is often deficient, possibly due to hypotonic muscles and muscle hypotrophy resulting from anatomical abnormalities [19,51]. This muscle weakness may lead to difficulties in swallowing, feeding, and chewing [7,19,52].

Patients with DS often experience difficulties in all three phases of swallowing. During the oral phase, challenges such as atypical chewing patterns, inadequate lip closure, a relatively large tongue, and malocclusion extend the duration food remains in the mouth. Anatomical irregularities and weakened masticatory muscles contribute to prolonged chewing times and decreased chewing frequency. In the pharyngeal phase, delayed muscle responses can increase the risk of choking. Additionally, incomplete mastication combined with reduced muscle tone in the digestive tract can lead to food and gastric acid reflux. This reflux is a potential precursor to gastroesophageal reflux disease (GERD), chemical erosion of the teeth, and suboptimal nutrition [53,54].

To manage feeding difficulties, the caregiver can support the cheek and chin, reduce the time of feeding, and place the patient in an upright position to avoid improper reactions. Early intervention and regular monitoring of body weight are essential to ensure proper nutrition for the growth of DS patients [55,56].

Mouth drooling in patients with DS is often attributed to incomplete lip closure, reduced oral cavity space, and an enlarged tongue. Compared to controls, individuals with DS exhibit an approximate 36% reduction in salivary flow rate [27].

3.5. Behavior management

Behavioral issues significantly impact the provision of appropriate dental care for patients with Down syndrome (DS). These individuals often exhibit refusal and uncooperative behaviors during dental treatments. Their selective attention deficits can contribute to difficulties in remaining engaged in a task [2,4].

There are traditional behavioral methods useful in managing dental fear and anxiety in these patients. Methods such as tell-show-do, positive reinforcement, distractions, shaping, and systematic desensitization are recommended [1].

While audiovisual distraction is an effective method for healthy individuals to distract attention from anxiety and fear in a dental clinic, it is less effective for DS patients. Traditional methods have a better effect than the audiovisual method for DS patients for a number of reasons. One of these could be that DS patients may have cognitive disorders. Another reason could be that the dentist cannot directly communicate with the patient during the treatment if audiovisual methods are used [4].

Pharmacological behavior management is essential to effectively manage disruptive behavior during dental treatment in DS patients. General anesthesia is widely used in dental clinics to treat DS patients with behavioral disorders. Oral sedation, such as the administration of Midazolam before treatment, is a relatively safe and short-acting option, with effects lasting 20 to 30 minutes [2].

The family plays a crucial role in the oral care of individuals with DS. Therefore, prioritizing oral hygiene education for families and establishing effective communication with dental professionals is imperative to protect DS individuals from oral diseases [38,57].

3.6. Physical therapy and early intervention

Early treatment intervention shows some positive effects on improving gross and fine motor control of Down syndrome patients [58]. Orthodontic treatment with an orthodontic palatal plate therapy (OPPT) is a method to correct physiological dysfunction, especially when combined with other treatments such as speech or manually stimulated physiotherapy treatment [1]. An orthodontic plate can provide the maximum contact for the maxilla and mandibular arches to improve the occlusal surface contact. An intraoral orthodontic appliance can improve the patient's mandible position, enhance activation, and increase masticatory frequency on the EMG, but it's still uncertain whether it makes the masticatory function more efficient [51,59]. Giannasi et al. noticed that applying neuromuscular electrical stimulation (NMES) on the masseter helps strengthen and maintain muscle mass. It can be the treatment of choice for hypotonic muscles and can improve physiological problems such as swallowing and mastication [60].

Active muscle training exercises, such as myo-functional therapy, have been shown to improve functional movement in DS patients aged 9 to 18 years [61]. Regular home exercises for children with DS have a positive effect on lip seal, activation of facial expression and strengthening of the masticatory muscles, changing the tongue from a protruding position to a proper resting position, and establishing proper nose breathing [62,63]. After this exercise protocol, mouth breathing, the wrong position of the tongue, incomplete lip seal, and hypotonicity of masticatory muscles can improve [61].

Carlstadt et al. mentioned the positive effect of special physical exercise and speech intervention on swallowing pattern and occlusion by improving the coordination of masticatory and facial muscle groups [63-65].

Down syndrome patients with temporomandibular joint (TMJ) disorders present with myofascial pain, restricted mouth opening, and bruxism [66]. To help these patients, physiotherapists can educate them on reducing forward head posture and coordinating strengthening exercises. Electrotherapy and manual therapy with facial massages for relaxation can also improve TMJ conditions [67-69].

According to Chen et al., mechanical motor-assisted cycling and voluntary exercises with music improve motor ability, which can help maintain proper oral hygiene [67]. Riding the modified bicycle with machine-assisted pedaling at high speed increases the sensory input from the gross motor exercise, which stimulates the motor cortex to improve fine motor skills of the upper extremities [70,71].

4. Conclusions

Understanding the oral health problems of individuals with Down syndrome is crucial for providing appropriate dental care and treatment planning. Dentists working with DS patients should develop individualized treatment plans to address the specific dental and facial characteristics unique to each patient. Regular dental assessments and early intervention, including physiotherapy and behavioral management, and a collaborative approach involving oral health professionals, caregivers, and the patients themselves are essential for preventing oral health problems and enhancing overall health and well-being.

Authors' contribution

N. Torlińska-Walkowiak: Methodology, Formal analysis, Writing—original draft, review and editing; Y.-W. Huang: Conceptualization, Investigation, Writing— original draft; S. Wyzga: Investigation, Writing—original draft; J. Opydo-Szymaczek: Supervision, Writing—review and editing.

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Conflict of interest

The authors declare no conflict of interest.

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