Review paper

Interdisciplinary dental care as a component of comprehensive treatment for patients with cystic fibrosis

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Abstract

This paper aims to identify the dental prevention and treatment needs of patients with cystic fibrosis (CF) and suggest implementation of dedicated dental health standards for such patients. Oral bacterial microbiota are a part of the upper respiratory tract microbiota, which is of crucial importance, especially for patients at risk of respiratory auto-infection. Parents and, later, patients themselves are not always aware of the harmful impact of the ongoing pathologies in the oral cavity on the whole body. Hence, educating on how to counteract auto-infection is necessary. CF patients are a group that require targeted dental care, and a dentist should be a member of a multi-specialist patient-care team. To improve the oral health of CF patients, it is advisable to implement overall solutions involving targeted preventive and therapeutic measures. Presented oral health standards of CF patients may affect their general health and quality of life.

Introduction

Newborn screening (NBS) for cystic fibrosis (CF) enables early diagnosis of the disease and thus early implementation of appropriate CF treatment and management, which undoubtedly improves CF patients' life quality and expectancy. A review of the screening programs' results carried out in 2007 showed that the prevalence of cystic fibrosis in Europe is 1 case for every 3500 births [1]. In Poland, the data show 1 child with CF in every 5750 births, which means about 70–80 new cases of CF per year [2]. Currently, there are approximately 2400 CF patients in Poland [2], while in the entire European Union (EU), the number reaches approximately 36,000 patients. With the total population of the EU being 486,114,000, this means a prevalence of 0.737 per 10,000. However, CF prevalence varies from 0.104 in Latvia to 2.98 in the Republic of Ireland (per 10,000) [3].

Essentially, the disease is due to a defect in the gene coding for the cystic fibrosis transmembrane conductance regulator (CFTR), which makes a chloride channel enabling passive transport of Cl^- ions according to their gradient across the cell membrane [4, 5]. Moreover, the channel regulates the diffusion of HCO_3^-, Na^+, K^+, and Ca^{2+} ions, as well as H_2O into and out of the cell. The CFTR is found in the apical part of the epithelial cell membrane of the respiratory tract, pancreatic ducts, gastrointestinal tract, bile ducts, sweat glands, reproductive system, and other cells derived from epithelium, including epithelial cells lining the secretory ducts of salivary glands and enamelogenic cells (ameloblasts) [4–9]. Therefore, abnormalities associated with the gene defect will appear wherever there are epithelial cells. The widespread presence of chloride channels in the human body explains why CF shows as a systemic disease, affecting many body systems and characterised by a polymorphism of clinical symptoms [2–5].

The condition of the oral cavity, being an integral part of the body, illustrates the general health of the host. Systemic diseases can manifest in the mouth. These manifestations are not always specific but may still affect the patient's quality of life and therefore should be considered in diagnostics and therapy. Thus, it is necessary to consider not only the very presence of CF, its course and complications, but also pharmacotherapy that begins early in life.

Although existing reports on the oral health of CF patients focus mainly on children and adolescents [10], improved diagnostics and treatment have extended life expectancy, highlighting the need for dental care guidelines, because oral pathologies may worsen systemic outcomes and contribute to respiratory infections. Caries and periodontitis have a multifactorial aetiology influenced by genetics, general health, medications, saliva properties, socio-economic factors, and, crucially, health behaviours like hygiene, diet, and regular dental check-ups [11].

A 2019 systematic review [10] emphasised the lack of dedicated dental protocols for CF patients despite evident treatment needs. Surveys show that adults with CF most often visit dentists due to pain or visible caries [12], indicating reactive rather than preventive

care. Poor oral hygiene and pathogenic biofilm accumulation are common [10, 12–17], often worsening during disease exacerbations. These findings highlight the urgent need for clear dental management guidelines for clinicians caring for CF patients.

This paper aims to identify the dental needs of CF patients regarding prevention and treatment, and suggests implementation of dedicated dental health standards for such patients.

Oral health needs of CF patients

Saliva makes a natural habitat for the teeth, periodontium, and mucous membranes lining the mouth. Its proper secretion, as well as its optimal composition and pH, ensure homeostasis and tissue hydration, which facilitate articulation, digestion, and swallowing. Saliva also protects the tooth surfaces and mucous membranes against the harmful effects of mechanical, biological, and chemical factors and participates in the perception of external stimuli, such as taste, temperature, and touch. In patients suffering from CF, as a result of damage to the CFTR protein gene, the transport of Na^+, K^+, Cl^-, HCO_3^-, and H_2O in the striated ducts of the salivary glands is disturbed, which results in reduced secretion and changes in physicochemical and, consequently, microbiological properties [18–20]. Undoubtedly, these abnormalities adversely affect the oral cavity, because the amount of saliva and its optimal composition not only determine the proper course of physicochemical processes but also contribute to maintaining ecological balance. In the studies by Pawlaczyk-Kamieńska *et al*. [12], conducted among adults only, the authors showed significantly lower resting hydration of the oral mucosa, increased saliva viscosity, lower pH of unstimulated saliva, and a lower amount of stimulated saliva secretion in CF patients compared to the results obtained from healthy people. According to the literature [18–20], hyposalivation and increased saliva viscosity in patients with CF may result from damage to the CFTR protein gene, although it may also be a side effect of the used pharmacological therapy and/or comorbidities. Symptoms of saliva deficiency that the patients may complain of include taste loss, a burning sensation in the mouth, difficulty chewing and swallowing food, and painful angular cheilitis. Moreover, the saliva profile of this group of patients may promote the accumulation of bacterial plaque and the progression of oral diseases, both caries and periodontitis.

Another health problem that may affect CF patients is enamelopathic dental malformations (enamel defects) [10]. These abnormalities have been recorded mainly on permanent teeth. The data published so far have been inconclusive and have shown a similar or significantly higher prevalence of enamel defects in permanent teeth in CF patients compared to the control group [21–24]. These mineralisation disorders appearing on CF patients' teeth have so far been interpreted in accordance with the course of CF itself, its complications, or chronic (often applied several times per year) antibiotic therapy during odontogenesis [7, 8]. The latest literature indicates that they may also be due to a defect in the CFTR protein gene, and thus a defective course of amelogenesis, because the enamel-forming cells responsible for the process are epithelial cells and contain a chloride channel that may be damaged in CF patients. An acid-base imbalance may result, as well as a decrease in the pH [25, 26] of the developing tooth germ environment, which promotes enamel defects. Regardless of the disorder's pathomechanism, it should be noted that the deviations that occur during the tooth bud development stage are irreversible [7, 8]. Further on, they unfavourably affect physical and chemical properties of the enamel after teeth eruption. They can potentially reduce tooth hardness and strength, and thus resistance to damaging mechanical and chemical stimuli, such as bacterial caries or non-bacterial erosion or abrasion of teeth. It is also suggested that greater susceptibility of hard tooth tissues to external factors predisposes the patient not only to the onset of but also to a faster pace of carious process [7, 8]. This may not only lead to tooth loss but also – through complications such as pulpitis or periapical tissue inflammations – produce a risk of a potential primary focus of infection to arise [27].

Based on the studies conducted so far, there is no clear answer about the increased risk of caries in patients with CF [10, 23]. It should be emphasised, however, that apart from the faulty resistance of tooth hard tissues to damaging factors, their state depends on numerous other systemic and local conditions, including general health, systemic and inhaled pharmacotherapy, the presence of pathogenic biofilm in the oral cavity, the amount and chemical and microbiological composition of saliva, consumed food (its type, composition, and number of meals), and in particular the need to apply a high-calorie diet. The key extrinsic aetiological factors acting directly on the tooth tissues in the initiation and progression of caries include pathogenic microorganisms (*Streptococcus mutans*, *Lactobacillus acidophilus*) accumulated as dental plaque, as well as sugar supplied with food or drugs, on which these microbes feed. High frequency of teeth exposure to cariogenic products produces the advantage of demineralisation over the remineralisation processes of the enamel and, consequently, the development of caries.

A crucial element (both for caries and periodontal disease prevention) in maintaining oral health is the control of bacterial biofilm through proper home and in-office hygiene procedures. Even with a slight accumulation of biofilm, inflammatory infiltrates are observed in the gingival tissues, resulting from the physiological immune control of the organism

[28]. If the balance between damaging factors and the host's immunity is upset due to the predominance of destructive factors (plaque retention) or to defence mechanisms being less effective, the symbiosis between the biofilm and the host's immune reaction is disturbed. Such dysbiosis promotes gingivitis, the only symptom of which the patient may note is gum bleeding on brushing [15–17].

A review of the literature [10, 15, 16, 29] showed that in both children and adults there were no statistically significant differences in the amount and spread of bacterial plaque between people suffering from CF and their healthy peers. Additionally, in the group of people under 18 years of age, there was no difference in the prevalence of gingival bleeding. On the other hand, gingival bleeding was statistically less frequent in CF adults than in the control group [10, 16]. When attempting to explain the lack of correlation between the presence of an inflammatory factor and the reaction of gingival tissues in CF patients, it becomes evident that the initiation and progression of the disease is not so much affected by the amount of bacterial deposit as by its composition and, above all, by microbiological pathogenicity. Not all microorganisms grouped as non-specific plaque biomass are responsible for the formation of pathological changes. It should also be taken into account that in CF patients, probably as a result of frequent and long-term pharmacotherapy over the years (also in the inhaled form), the plaque pathogenic potential may be lowered and an individual, and specific ecological balance of the biofilm is quite likely [16]. However, this balance disturbance cannot be ruled out, and, especially considering the nature of CF patients' saliva, it may bring about unpleasant consequences, such as periodontal or mucous membrane diseases (e.g. bacterial and fungal inflammations).

Recommended dental consultation schedule for CF patients

Understanding the mechanisms ruling the oral cavity environment of CF patients as well as the impact of the oral microbiome on other organs seems to be very helpful in choosing a strategy aimed at preventing oral diseases in these patients. As the research shows [10], despite the progress in CF patients' care, their oral health proves that prophylaxis of oral diseases is inadequate for their needs and that there is a significant need for treatment. CF patients comprise a group that requires targeted dental care, and a dentist should be a member of a multi-specialist patient-care team. The published data show that the need for periodic oral health check-ups in CF patients is indisputable. Referring a CF patient for dental check-ups at specific stages of the stomatognathic system development seems to be of significance (Table 1). This would allow for the assessment of how the dentition, jaws, and temporomandibular joint develop and the detection of possible pathological lesions in the craniofacial area, including masticatory dysfunctions or parafunctions. It would also give an opportunity to judge the risk of diseases, such as caries and periodontal or mucosal diseases, which are related to salivary disorders, among others.

Parents of a CF child should be referred for the first dental consultation after the diagnosis of the underly-

Table 1. Recommended dental consultation schedule for CF patients

Variable	At the time of CFdiagnosis	6–12 months	3 years	6 years	9 years	12 years	18 years and older
An explanation of the possible oral risks associated with CF	●	●	●	●	●	●	●
Targeted oral health education	●	●	●	●	●	●	●
Oral hygiene instruction	●	●	●	●	●	●	●
Dietary counselling	●	●	●	●	●	●	●
Counselling for non-nutrive habits		●	●	●	●	●	●
Clinical dental examination		●	●	●	●	●	●
Assessment of dental and oral development		●	●	●	●	●	●
Oral diseases risk assessment		●	●	●	●	●	●
Caries and periodontal prophylaxis		●	●	●	●	●	●
Assessment of developing malocclusion			●	●	●	●	●
Assessment of oral moisture degree				●	●	●	●
Establishing a strategy for preventive and treatment interventions	●	●	●	●	●	●	●

ing disease has been made but not later than before the age of 12 months, as is the case with healthy children. A subsequent consultation should be due when all milk teeth have erupted (i.e. before 3 years of age) and the next one with the onset of permanent teeth eruption (6 years of age). The half-time of the milk-to-permanent dentition exchange takes place around the age of 9 years, and this too is a suitable time to refer a child to the dentist. The following visit should be scheduled after all permanent teeth have erupted, which is around 12 years, and the next after the age of 18 years. Similarly, adult patients should be subjected to periodic dental check-ups. The proposed dates of dental consultations within developmental age coincide with stages of the growth of the stomatognathic system. They do not differ from the schemes designed by paediatricians, and their results should be reported to the attending physician. Periodic dental check-ups for all CF patient age groups are obviously recommended, at least every 6 months, unless more frequent visits are required due to therapeutic or prophylactic needs [29].

The American Academy of Pediatric Dentistry (AAPD) recommends the implementation of prophylactic measures of oral diseases as early as the perinatal and infant period. Prevention applied at this stage lays the foundation for oral health and increases the child's chances of keeping the oral cavity free of preventable diseases, including dental caries [30]. During this period, prophylaxis is based mainly on educating parents on the oral hygiene of infants and young children, dietary counselling, caries risk assessment, and establishing a strategy for prophylactic and, if necessary, therapeutic interventions.

Dental care should also be provided to pregnant women, who, aside from dental education and check-ups, should be offered prophylactic procedures. Mothers-to-be should be made aware that odontogenesis begins in the sixth week of foetal life, and any inflammation in their mouth may adversely affect the course of pregnancy and the foetus. Also, maternal systemic diseases, applied medications, nutritional deficiencies, or the impact of teratogenic factors during pregnancy may adversely affect the development of teeth. Pregnant women should therefore be encouraged to eat healthy, rational diets, practice meticulous oral hygiene, and attend regular dental check-ups.

In the case of children who have already been diagnosed with CF, prophylaxis that can significantly reduce caries and thus prevent its harmful consequences should be started as early as possible. The first meeting of parents with the dentist should be scheduled in the first weeks of a child's life. Such a visit is primarily designed to explain to parents the possible risks of oral diseases resulting from the underlying disease and its treatment, as well as to plan dental prevention and therapy. Parents should be informed that their oral cavity is the main reservoir of cariogenic microorganisms that can be transmitted through kisses, pacifiers, or spoons to the child's mouth. Therefore, to assess the risk of an infant's oral infections, it is advisable to check the parents' oral health and hygiene, as well as to analyse their dietary habits. To break the chain of infection, it is important to identify parents' treatment needs and deal with them. The first visit should also include providing oral hygiene instruction with regard to the child's toothless mouth, as well as dietary education. The parents of a child are fundamentally important in formulating their baby's dietary and oral health behaviours, so parent education is a crucial stage.

According to the recommendations of the AAPD [31] and the American Dental Association (ADA) [32], the first visit to the dentist and examination of the child should take place between 6 and 12 months of age. It seems that, for CF patients, such a visit is also indicated.

Dental check-ups in children, depending on their risk of tooth decay, should be done at least every 6 months. The purpose of these is to monitor the effectiveness of home hygiene procedures, to assess the state of dentition (its development stage, structure, and the diseases of hard dental tissues) and the risk of oral diseases. Parents' attention should be drawn to dysfunctional habits and para-functions of the masticatory system (e.g. finger sucking, nail biting, grinding), which may give rise to maxillofacial defects. Each visit should include oral hygiene procedures and dietary and hygienic instruction, as well as exogenous fluoridation via the application of fluoride varnishes, if needed.

In older children and in adults with CF, a properly elicited history should reveal the risk of oral diseases based on healthy behaviours such as hygiene and dietary habits, the use of fluoride compounds, and dysfunctions and para-functions of the masticatory organ. Apart from that, the questions should cover any symptoms of dry mouth. Clinical examination should focus on the condition of the teeth and periodontium, assessment of the stomatognathic system, and possible needs for orthodontic intervention, as well as the quality of mouth moisturisation. Additional saliva tests can also be performed to determine the amount of saliva secretion, along with its pH and bacteriological composition.

If the tests reveal hyposalivation, dry mouth problems should be addressed as well as implementing standard preventive procedures, such as oral hygiene instruction, dietary recommendations and the use of fluoride varnishes. Dry mouth treatment is symptomatic only and consists of frequent rinsing of the mouth with water or the use of special sprays or rinsing liquids to improve mouth hydration. The feeling of dryness can also be effectively relieved by 'artificial saliva', which forms a moist, protective layer on the oral mucosa.

The dental check-ups in CF patients should be done at least every 6 months, but their frequency

should be individually determined depending on health and the risk of oral diseases. It should be emphasised that the health of the oral cavity belongs to and impacts general human health [10, 11] and therefore should be of concern to CF patients' carers, especially because the patients are at risk of respiratory tract auto-infection.

Discussion

In recent years, researchers have increasingly focused on the oral health of CF patients and its impact on their overall well-being [10–17, 20–22, 24, 27, 29]. However, there remains a significant gap in dental treatment protocols specifically tailored for this population.

A critical factor influencing oral health in CF patients is the impaired function of the salivary glands. A study by Pawlaczyk-Kamieńska *et al.* [12] observed that the average pH level of saliva in adult CF patients was notably lower (6.3 ±0.4) compared to that of healthy individuals (6.9 ±0.2). Furthermore, the mean stimulated saliva flow in CF patients was around 44% lower than in the control group [12].

A comprehensive review of existing literature examining developmental enamel defects in primary teeth has not revealed statistically significant differences between CF children and their healthy counterparts. However, studies have documented the presence of enamel defects in the permanent teeth of adolescents with CF [10, 21, 22], while data regarding the incidence of such defects in adult populations remains sparse [22]. Ferrazzano *et al.* [21] found a significantly higher prevalence of enamel defects in CF patients (55.6%) compared to controls (22.7%), a finding supported by Pawlaczyk-Kamieńska *et al.* [24], who reported 55% of adult CF patients affected versus 23% in controls, with more extensive tooth involvement (7.41–100% vs. 7.14–36%); in contrast, Peker *et al.* [22] found no significant difference between groups (20% vs. 23.3%).

Research indicates that caries intensity does not differ significantly between CG children and their healthy counterparts [10, 13, 14, 21]. However, findings regarding caries intensity in adult patients are more heterogeneous. While Matrens *et al.* [13] found no significant difference in caries prevalence between adults with CF and controls, Pawlaczyk-Kamieńska *et al.* [24] reported a higher caries intensity in CF adults, with more active caries and extractions. Additionally, Pawlaczyk-Kamieńska *et al.* [24] found no difference in the number of treated teeth, yet none of the CF patients were caries-free, compared to 14% in the control group. The poor dental health of CF patients may be partly because, as shown by Pawlaczyk-Kamieńska *et al.* [11], they typically seek dental care only in response to pain or visible lesions, indicating a reactive rather than preventive approach.

Conclusions

Raising dental health awareness among CF patients is essential for improving their overall health. Oral bacteria play a significant role in respiratory infections, making it crucial for patients and their families to understand the impact of dental health on the body. A team approach involving medical professionals, including dentists, is vital for effective CF management.

Establishing dental care standards for CF patients can enhance their quality of life. Recommended dental consultations should align with children's growth stages and meet the individual needs of adults. Implementing targeted preventive and therapeutic measures is important, and appropriate regulations are necessary for these care standards to become common practice.

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Conflict of interest

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