Ovrednotenje uspešnega zdravljenja pacientov z enostranskim funkcionalnim križnim grizom

Evaluation of successful treatment of patients with unilateral functional crossbite

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Izvleček

Namen: *Enostranski funkcionalni križni griz (EFKG) je ena najpogostejših ortodontskih nepravilnosti v mlečnem in zgodnjem menjalnem obdobju. Spremlja ga lateralni zdrs spodnje čeljustnice ter neskladje zgornje in spodnje središčnice zobnega loka zaradi ožje zgornje čeljustnice. S študijo smo želeli oceniti učinkovitost zgodnje obravnave EFKG s funkcionalnim ortodontskim aparatom po Fränkelu tip 3 (FR–3).*

Metode: *V študijo smo vključili 90 pacientov (32 dečkov in 58 deklic) z EFKG, povprečne starosti 6 let in 8 mesecev (SD ±1,8), obravnavanih s FR–3. Diagnostični postopek je temeljil na anamnezi, kliničnem pregledu, analizi orofacialnih funkcij, analizi rentgenograma in analizi študijskega modela. Učinkovitost zdravljenja je temeljila na analizi študijskega modela pred in po ortodontski obravnavi.*

Rezultati: *Obravnava EFKG je*

Abstract

Purpose: *Unilateral functional crossbite (UFCB) is one of the most common malocclusions in the deciduous and early mixed dentition stage. It is accompanied by lateral mandibular shift and mandibular midline deviation due to the narrow maxillary dental arch. The aim of this study was to assess the effects of early correction of UFCB with the Fränkel (FR–3) functional regulator.*

Methods: *Ninety Caucasian subjects (32 boys and 58 girls) with UFCB in the early mixed dentition stage (mean age, 6 years and 8 months (SD±1.8)) were treated with the FR–3 functional regulator and monitored. The diagnosis was based on anamnestic data, clinical examinations, radiographs, and analyses of study cast models. Dental casts taken before and after treatment were used in the analysis of effects.*

Results: *Treatment of UFCB involved expansion of the maxillary arch,*

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vključevala odstranitev okluzijskih motenj, širjenje zgornje čeljustnice in odstranitev funkcionalnega zdrsa spodnje čeljustnice v stran (lateralno). Širina zgornje čeljustnice se je povprečno povečala za 2,90 mm (SD±1,63) v področju podočnikov in 2,78 mm (SD±1,60) v področju kočnikov. Druga prednost zgodnje obravnave je povečanje dolžine zobnega loka za stalne sekalce, ki potrebujejo več prostora. Pri 69 (76,67%) pacientih z EFKG je bila prisotna vsaj ena nepravilna orofacialna funkcija. Ob koncu zdravljenja so bili odpravljeni vsi križni grizi in funkcionalni zdrsi spodnje čeljustnice, prav tako 2 leti in 8 mesecev po zdravljenju ni bilo ugotovljenega recidiva.

Zaključek: *Regulator funkcije po Fränkelu tip 3 je učinkovit funkcionalni ortodontsko–ortopedski aparat za zdravljenje EFKG. S terapijo smo dosegli značilno izboljšanje odnosa zgornje in spodnje čeljustnice ter s tem izboljšane pogoje za normalno rast in funkcijo stomatognatega sistema.*

removal of occlusal interferences, and elimination of the functional shift. The width of the maxilla increased by 2.90 mm (SD±1.63) in the canine region and by 2.78 mm (SD±1.60) in the molar region. Another advantage of early treatment was improvement of maxillary arch length deficiency secondary to maxillary constriction because the permanent incisors were afforded more space before or during eruption than if the crossbite was treated at a later age. At least one abnormal orofacial function was identified in 69 (76,67%) patients with UFCB. After treatment, all crossbites were corrected, functional deviations were eliminated, and no relapses were observed during follow–up at 2 years and 8 months.

Conclusion: *The Fränkel functional regulator is a functional orthodontic–orthopedic device that is an effective alternative for the treatment of UFCB. Dental occlusion was significantly improved, and the prognosis for normal craniofacial growth and normal function of the stomatognathic system was enhanced.*

INTRODUCTION

Unilateral functional crossbite (UFCB) is one of the most prevalent malocclusions in the early mixed dentition stage, with the prevalence of UFCB ranging from 4% to 22% (1–4), although results of epidemiological studies vary due to the examined cohorts and study criteria. The etiology of UFCB is complex, and it can include any combination of dental, skeletal, and neuromuscular components, but the most frequent cause is a reduction in the width of the maxillary dental arch. Such a reduction can be induced by finger sucking or abnormal nasal breathing caused by obstruction of the nasopharynx, enlarged tonsils and adenoids, or chronic respiratory obstruction in children with nasal allergies (5–9).

In children, the interrelation of maxillary and mandibular teeth is variable between the centric and the maximum intercuspidal position. In the centric relation of the condyles with midline concordance, the lower teeth do not occlude in a maximum cuspid–fossa relationship. This unstable maxillomandibular cuspid occlusion results in a functional shift of the mandible, thereby causing maximum occlusion

and UFCB with midline deviation (1, 2, 7,10). The condyles on the crossbite side are positioned more superiorly and posteriorly in the glenoid fossa than those on the noncrossbite side. As skeletal remodeling of the temporomandibular joint (TMJ) can occur over time, the condyles become more asymmetrically positioned in their fossa, and facial asymmetry and mandibular midline deviation toward the crossbite side can persist (11).

Children with UFCB exhibit greater facial asymmetry than children without this malocclusion in all the dentition phases examined, with the greatest differences observed in the lower part of the face. However, in cases of UFCB, facial asymmetry in the middle part of the face is clinically relevant when combined with the transition from the primary to the mixed dentition phase (12).

If untreated, the crossbite and the abnormal lateral movement of the lower jaw can strain orofacial structures, thereby adversely effecting the temporomandibular joint, the masticatory system, and facial development (3,13). Thus, early treatment eliminates the likelihood that UFCB will progress to a skeletal malocclusion, a condition that may require extensive orthodontic and surgical treatment (2,14).

There are a variety of treatments available for the correction of UFCB such as selective grinding of teeth, plate expansion, the quad helix, or rapid maxillary expansion (15–20). Recently, there has been increased interest in functional orthopedic treatment modalities. Fränkel emphasized the importance of the soft tissue environment, maintaining that aberrant postural behavior of the orofacial musculature plays a primary role in the development of skeletal and dento–alveolar deformities (21). Rolf Fränkel and his daughter Christine Fränkel described the functional regulator as: "(the) function regulator appliance is capable of producing maxillary expansion in the alveolar basal area even after the permanent premolars have erupted. We believe that the pull of the projecting buccal shields of the function regulator on the soft tissues at the sulci is transferred to the periosteum which results in deposition of the new bone on the buccal aspect of the alveoli with subsequent remodeling of the outer alveolar walls" (22).

The present study evaluates transversal dento–alveolar changes in subjects with UFCB, who were treated with the functional regulator by Fränkel (FR–3).

METHODS

Materials

The materials used in this study were anamnestic data, clinical examinations, study casts, and radiographs of 90 Caucasian patients with UFCB treated at the Orthodontic Department. The inclusion criteria were as follows: (i) patients with unilateral functional crossbite (only subjects with all posterior teeth in the crossbite on one side and midline deviation (Figure 1a, b) due to a functional mandibular shift were included (Figure 2)), (ii) patients in the early mixed dentition stage, (iii) patients with no previous orthodontic treatment, (iv) patients with no class III malocclusion, (v) patients whose study casts were available pretreatment (T1) and post–treatment (T2), (vi) patients with no craniofacial deformities, and (vii) those with no tooth aplasia. The selection criteria were also applied to the good quality study models and all deciduous teeth, except deciduous incisors which could be replaced with permanent incisors in the early mixed dentition stage. Based on these criteria, records of 90 Caucasian patients (32 boys and 58 girls), with a mean age of 6 years and 8 months (SD±1.8) were collected and treated with the FR–3 functional regulator.

Ethical approval for this study was obtained from the Slovenian National Medical Ethics Committee (No. 49/01/11 bis).

Methods

Abnormal chewing function data were obtained during clinical examination. To assess the presence of UFCB, each patient was asked to close and open his/her mouth three times during the same visit. A functional examination of the mandible closing pathway from maximum opening to first contact, as well as the final and maximum intercuspation, was performed to determine if a lateral or an anterior–posterior mandible shift occurred following first contact. Each patient was asked to open his/her mouth as wide as possible and keep it opened for a short period of

Figure 1a, 1b. *In the study were included only the subjects with all the posterior teeth in crossbite on one side (example of right–side crossbite Figure 1a or left–side crossbite Figure 1b) and midline deviation due to a functional mandibular shift*

Figure 2. *Functional mandibular shift to right side with facial asymmetry*

time to confuse or eliminate proprioceptive memory. Possible mandible shifting was then evaluated by asking the patient to close the mandible slowly from maximum opening to first contact of centric occlusion and then to maximum intercuspation. The amount and direction of any mandible shifting between first contact and maximum intercuspation was noted. Only subjects with all posterior teeth in the crossbite on one side and midline deviation due to a functional mandibular shift were included.

Each patient was treated with the FR–3 functional regulator. Bite was registered by guiding the mandible laterally to correct upper and lower midline relation. The device was individually manufactured and made of acrylic resin and resilient stainless–steel wire (Figure 3a, b).

Patients were instructed to wear the device during the first three weeks for 5 hours during the day for slow adaptation. After this time, patients were instructed to wear the device for 16–18 hours per day. The device and treatment process were checked at 6–week intervals. Active functional treatment was terminated when the posterior crossbite were corrected.

Study casts were obtained from all subjects before and after active treatment. On the study casts, linear measurements were carried out to assess dento–alveolar changes. Dental arch widths were also measured using reference points corresponding to canine and first permanent molar teeth in both jaws, which are the projection of each other.

The following measurements were recorded:

- Maxillary transversal measurements
  The maxillary intercanine transversal width was defined as the linear distance between the right and left maxillary deciduous canine cuspids. The maxillary intermolar transversal width was defined as the linear distance between the deep–est points of the central fossa of the right and left maxillary first permanent molars.
- Mandibular transversal measurements
  The mandibular intercanine transversal width was defined as the linear distance between the right and left mandibular deciduous canine cuspids.

Figure 3a, 3b.. *Each patient was treated with an individually manufactured functional regulator (FR–3) appliance with functional bite registered by guiding the mandible laterally to correct upper and lower midline relation*

The mandibular intermolar transversal width was defined as the linear distance between the disto–buccal cusps of the right and left mandibular first permanent molars.

- Midline deviation
  The midline deviation was measured in the frontal plane as the distance between the upper and lower midlines on the occlusal plane. The intercanine width distance, intermolar width distance, and midline deviation were measured with a caliper.
- Orthodontic treatment goals for the patient treated with the FR–3 functional regulator included rehabilitation of jaw relationship in the transversal plane, achievement of normal dental occlusion (to eliminate the posterior crossbite), and improvement of function (i.e., nasal breathing, tongue posture).

Statistical analysis

To eliminate measurement errors, all measurements of study casts were obtained systematically under standardized conditions by two orthodontists (AF and JŠK). Mean findings were statistically evaluated. Five linear parameters were measured in this study. SPSS 10.0 software (SPSS Inc., Chicago, Ilinois, USA) was used for the statistical analysis of registered variables. Mean and standard deviations (SD) were calculated for all variables at T1 an T2. Results were regarded as significant at $p<0.05$.

RESULTS

Our results are based on the maxillary and mandibular intercanine and intermolar widths of patients with UFCB with midline deviation and abnormal chewing function. The mean maxillary and mandibular intercanine and intermolar arch widths, as well as the midline deviation before treatment (T1), are presented in Table 1. Measurements showed that the width of the maxilla increased by 2.90 mm (SD±1.63) in the canine region and by 2.78 mm (SD±1.60) in the molar region (Table 2). The maxillary intercanine and intermolar arch widths were statistically significantly increased ($p<0.05$). Before treatment (T1), the patients showed a midline deviation of approximately 1.92 mm (SD±0.74). After treatment, the midline deviation was significantly reduced ($p<0.05$).

At least one abnormal orofacial function was identified in 76,67% of patients with UFCB. The most common abnormal orofacial functions were pacifier sucking, lip incompetence (i.e., abnormal nasal breathing), and abnormal tongue position at the base of the mouth.

The average time needed to correct the crossbite was 15±7 months. Early orthodontic treatment eliminated occlusal disturbances, and the corrected bite remained stable during follow–up at 2 years and 8 months. Patients also felt the FR–3 functional regulator was comfortable to wear. Patients did not

Table 1. *Comparison of pre–treatment measurements*

Dental arch widths	Group	TI	
		Mean	SD
Maxillary intercanine width (mm)	M	31.29	3.41
	F	31.32	3.30
Mandibular intercanine width (mm)	M	30.49	3.71
	F	30.46	3.88
Maxillary intermolar width (mm)	M	42.84	2.97
	F	42.89	2.63
Mandibular intermolar width (mm)	M	46.40	3.22
	F	46.44	2.81
Midline deviation	M	1.93	0.76
	F	1.92	0.73

complain of problems while wearing the device, and speech was not disturbed.

DISCUSSION

When a lateral functional shift is caused by a maxillary transverse deficiency, the maxilla should be expanded as soon as it is diagnosed. It has been previously reported that subjects with UFCB already exhibit greater facial asymmetry in the primary and early mixed dentition phase than subjects without UFCB (9,12,17). Lippold et al. reported early orthodontic treatment as temporomandibular functional prophylaxis because early treatment showed a significant reduction in condylar deviation and an improvement in occlusion and function (23). Many studies have indicated that untreated UFCB can worsen during growth, thereby resulting in permanent skeletal asymmetry (24–26).

Several studies have been carried out during the last decade on the early treatment of posterior crossbite by opening the midpalatal suture (15, 16,18–20). This study was conducted on growing patients, and treatment was started in the early mixed dentition stage using the FR–3 functional regulator. Fifty–eight patients (64,4 %) with UFCB were girls. These findings differ from those reported by Kutin and Hawes who found no sex difference associated with the prevalence of UFCB (2). It is possible that the sex difference with regard to the prevalence of crossbite can be due to referral patterns, as there is evidence to suggest that more girls are referred to an orthodontic practice and more girls pursue treatment after being referred to an orthodontic practice. In an epidemiological study by Helm, the crossbite prevalence was significantly higher in girls than in boys (27).

In the present study, comparisons of initial values showed that the maxillary intermolar arch width was significantly smaller than the mandibular

Table 2. *Difference in mean changes (T1 to T2) standardized*

Dental arch widths	Group	T1	
		Mean	SD
Maxillary intercanine width (mm)	M	2.91*	1.61
	F	2.90*	1.63
Mandibular intercanine width (mm)	M	0.72	0.57
	F	0.73	0.71
Maxillary intermolar width (mm)	M	2.79*	1.48
	F	2.78*	1.68
Mandibular intermolar width (mm)	M	0.89	0.71
	F	0.85	0.83
Midline deviation	M	1.66*	0.81
	F	1.62*	0.69

*$P< 0.05$

intermolar arch width in both gender groups. This finding indicates that the subjects had transversal maxillary deficiencies. During treatment with the functional regulator, the maxillary intercanine width increased by 2.90 mm (SD±1.63) ($p<0.05$) and the maxillary intermolar width increased by 2.78 mm (SD±1.60) ($p<0.05$). This expansion is less than that reported by Huynh et al. because our cohort included only UFCB cases, not unilateral and bilateral crossbite cases together (28). These results are comparable to those reported by Bell and LeCompte and Boysen et al., who used methodologies similar to those used by us to treat 8–year–old patients, but with the quad helix (18, 19). These findings show that the early correction of UFCB has a positive influence on the further development of the maxilla and can prevent the abnormal transverse growth of the lower arch in the intermolar region.

Finally, it has been postulated that a constricted maxilla can reduce the space required to accommodate the permanent maxillary incisors, and in such cases maxillary expansion is often necessary to provide adequate dental arch space. In this study, the maxillary intercanine width increase had significant clinical value in children with insufficient space for their permanent maxillary lateral incisors.

The correlation between abnormal orofacial function (i.e., sucking habits, abnormal nasal breathing, abnormal tongue posture) and UFCB has been extensively investigated (5–7). These studies have indicated that during finger and pacifier sucking, the tongue is forced into a lower position in the mouth, thereby reducing the pressure of the tongue against the palatal surfaces of the maxillary canines and molars, and such pressure normally counteracts the pressure of the cheeks. Thus, the pressure caused by the musculature activity of the cheeks, in the absence of counter pressure from the tongue against the palatal surfaces of the maxillary teeth, results in

a narrower upper arch. The same findings have been reported in patients with abnormal nasal breathing, and they are caused, for example, by the obstruction of the nasopharynx, enlarged tonsils, or chronic respiratory obstruction in children with allergies (7–9). In this study, we identified at least one abnormal orofacial function in 69 (76.67%) patients with UFCB. The most common abnormal orofacial functions were pacifier sucking, lip incompetence (i.e., abnormal nasal breathing), and abnormal tongue posture at the base of the mouth. Muscle imbalance created transverse disharmony that increased the likelihood of crossbite development with lateral mandibular shift and mandibular midline deviation due to the reduction in the width of the maxillary dental arch. The buccal shield of the FR–3 functional regulator restores muscle balance and confirms Moss's theory of the functional matrix (29). Our findings showed that maxillary dental and alveolar widths increased significantly after using the FR–3 functional regulator, while dento–alveolar widths of the mandible changed minimally. These findings are consistent with the results of Fränkel and Kalavritinos who observed an increase of the maxillary dento–alveolar width (21, 30). Treatment of UFCB involves removal of occlusal interferences and elimination of functional shift to allow expansion of the maxillary arch by stimulated growth. In such cases, overexpansion is not necessary because no relapse occurred. The use of the FR–3 functional regulator normalized the occlusion in a functionally optimal position of the mandible.

Maxillary expansion can be rapidly achieved (i.e., over 2–3 weeks), using, for example, a rapid maxillary expander (RME), or gradually (i.e., over 3–14 months), using, for example, the quad helix or an expansion plate (15,16,18–20). The difference in expansion rates reflects differences in the frequencies of activation, magnitude of the applied force, duration of treatment, and proportion of dento–alveolar to skeletal effects. Skeletal effects imply the opening of the midpalatal suture. In this study, the mean time taken for the functional regulator to achieve corrected maxillary expansion by growth was 15 ±7 months. Furthermore, the overall treatment time was longer than the treatment time with an expansion plate or a quad–helix, which opened the midpalatal suture. However, our device was more comfortable for patients. These results show that the FR–3 functional regulator is an appropriate and successful treatment device for the correction of UFCB. However, patient compliance is an important determinant of the effectiveness of treatment.

CONCLUSIONS

Orthodontic treatment of UFCB with a functional regulator in the early mixed dentition stage is an effective therapeutic methodology, as evidenced by the results of this study. It causes maxillary growth effects with correction of the transverse dento–alveolar discrepancies. Dental occlusion is significantly improved, and the prognosis for normal craniofacial growth is enhanced. The study confirmed that if UFCB of dento–alveolar origin is successfully corrected by the FR–3 functional regulator, then long term stability is achieved and the progress is favorable.

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CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

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