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REVIEW ARTICLE

Functional appliances in contemporary orthodontic practice

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INTRODUCTION

The term functional appliance refers to a large and diverse family of orthodontic appliances designed mainly to correct Class II malocclusion. They were developed primarily in Europe but have been adoptedby orthodontists in many countries. They all work by posturing the lower jaw forward, the stretched musculature and soft tissues creating a force, which is transmitted to the dentition. In addition, the soft tissue envelopesurrounding the teeth is changed. This results in tooth movement, establishment of a new occlusal relationship and reduction of the overjet. The efficiency of these appliances in the correction of sagittal discrepanciesin growing patients has intrigued orthodontists for many years, particularlythe question of whether they significantly affect skeletal growth. There has been a lot of mystery and misinformation associated with their use, often supported by quasi-scientific theories of growth.[1] Many of the claims made in association with these appliances are in the form of case reports, or retrospective studies, using unreliable and over-complicated cephalometric analyses, with all the inherent bias associated with these types of study.[1] More recently, the results of several large prospective clinical trials have provided the best evidence of what these appliances can do and equally importantly, whatthey do not do.The development and use of functionalappliances was pioneered in Europe early in the twentieth century, at the same time thatfixed appliances were being developed inthe USA. A simple monobloc appliance wasdescribed by Pierre Robin in 1902 for use inmandibular retrognathia and functional jawexpansion, it was the precursor of the applianceused for the treatment of Class II malocclusionsdescribed by Viggo Andresen while working at the dental school in Oslo. The storygoes that following fixed appliance therapy on his daughter he fitted her with a modifiedupper Hawley type retainer with a lowerlingual flange that guided the mandible forwardinto an ideal inter-arch relationship. Theappliance was fitted as a retainer during herthree-month summer holidays to be worn atnight, and it corrected her Class II relationship.Andresen refined the technique and appliance,with the assistance of Karl Häupl, and coinedthe phrase ‘functional jaw orthopedics’ toencapsulate their philosophy of how the appliancesworked. A detailed history on functionalappliances and the personalities involved hasbeen published by Levrini and Favero.[1-5]

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lower jaw forward,the stretched musculature and soft tissuecreating a force, which is transmitted to thedentition. In addition, the soft tissue envelopesurrounding the teeth is changed. This results in tooth movement, establishment of a new occlusal relationship and reductionof the overjet. The efficiency of theseappliances in the correction of sagittal discrepanciesin growing patients has intriguedorthodontists for many years, particularlythe question of whether they significantlyaffect skeletal growth. There has been a lot ofmystery and misinformation associated withtheir use, often supported by quasi-scientifictheories of growth. Many of the claims madein association with these appliances are inthe form of case reports, or retrospectiveFunctional appliances have been used for over 100 years in orthodontics to correct Class II malocclusion.[6-8] During this timenumerous different systems have been developed often accompanied by claims of modification and enhancement ofgrowth. Recent clinical evidence has questioned whether they really have a lasting influence on facial growth, their skeletaleffects appearing to be short term. However, despite these findings, the clinical effectiveness of these appliances is acknowledgedand they can be very useful in the correction of sagittal arch discrepancies. This article will discuss the clinicaluse of functional appliances, the underlying evidence for their use and their limitations.designs have been described usually bearingthe name of their inventor and incorporatingcomponents reflecting their philosophy.Functional appliances all have a posturaleffect on the mandible, although how this isachieved and the auxiliary components theyincorporate vary between different systems.[8-12]

REMOVABLE FUNCTIONAL APPLIANCES

ACTIVATORS

The original Andresen-Häupl activator wasconstructed from a single block (or monobloc)of Vulcanite, which was later replacedby acrylic. The postural element ofthe appliance is achieved by a lingual extensionof the bloc in the lower arch. It wasdeliberately made loose to encourage activationof the protractor and elevator musclesto keep it in place. Apart from this posturaleffect it is designed to be a passive appliance,although guided eruption of the buccaldentition can be achieved by facets cutinto the bloc. Numerous variations of theactivator have been developed. Increasedvertical opening of the appliance has beendescribed by Herren, Harvold and Woodside.An increase in vertical opening beyond thefreeway space supposedly activates the viscoelasticpull of the tissues, similar to thestretch reflex, as opposed to just relying onactivation of the muscles.[12-15] Other activatorsare designed for use with headgear to restrainmaxillary growth, such as the Teuscher appliance. This appliance incorporatesspurs on the upper incisors to prevent lingualtipping of the teeth while high-pull headgearis applied. Another variation of the activatoris the Bionator developed by Wilhelm Balters,who reduced the bulk of the appliance makingit easier to wear. Others such asthe Bass or Dynamax appliances removedirect contact with the lower incisors to tryand prevent their proclination. Posturing ofthe mandible forwards is achieved by lingualspurs or springs that sit in the mandibularlingual sulcus. The most significant modifications of theactivator appliance are the function regulatorsdeveloped by Rolf Fränkel in the formerGerman Democratic Republic.[16,17] Theseappliances are deliberately designed to haveminimal tooth contact and consist of a metalframework with buccal shields and anteriorlip pads designed to relieve cheek and lippressure and disrupt any abnormal perioralmuscular activity. Fränkel developedthese appliances to be worn full timecombined with oral exercises and, of all thefunctional appliances, the function regulator is probably the one that lives up to best tothe description of functional.[18-23]

TWIN BLOCKS

All the activator variations described above areessentially one-piece appliances. This meansthat they cannot be worn during eating. Toovercome this, William Clark developed theTwin Block appliance, which consistsof upper and lower removable appliances withbite blocks composed of bite ramps set atabout 70 degrees. When occluding, the lowerblock bites in front of the upper to posture themandible forwards. Generally, the Twin Blockappliance is robust and well tolerated, and hasbecome very popular in the UK.[23-26]

FIXED FUNCTIONAL APPLIANCES

A major problem with any removable functionalappliance is compliance, because theydo not work unless they are worn for therequired number of hours each day. This canbe overcome by the use of a fixed functionalappliance. The most well-known and popularfixed functional appliance is the Herbstappliance. This was first described by EmilHerbst in 1905, which makes it almost asold as the specialty of orthodontics itself.However, it disappeared into obscurity untilit was rediscovered and popularized by HansPancherz in the late 1970s.[6] Since then, it has grown in popularity and is now one ofthe most widely used and researched functional appliances in the world. It consistsof separate superstructures cemented to themandibular and maxillary dentition, and constructed from either orthodontic bandsor cobalt chromium cap splints connected bytelescopic pistons that provide the protrusiveforce to the mandible. Such is the prevalence of Class II malocclusionin developed countries and the desirefor a predictable and compliance-free way ofcorrection that numerous variations of thefixed Class II corrector based on the Herbstprinciple have been described. They usuallyhave exciting and promising names but mostare introduced without being properly clinicallytested. A few persist and prove to beclinically useful. An example of this is theFORSUS® spring from 3M. This is similar indesign to the Herbst, but attaches directly tothe molar bands of a fixed appliance and thelower arch. It consists of a piston and nickeltitanium spring that produces a protrusiveforce on the lower dental arch.[27-32]

HOW DO FUNCTIONALAPPLIANCES WORK?

There is no doubt that a functional appliancein a growing patient can be very effectivein reducing even a very large overjet.However, controversy remains about howthey actually achieve this. Proponents oftheir use believe they have a direct andlasting effect on the facial growth, particularlyof the mandible. Evidence for this hasproved elusive and they appear to work bya combination of altering the soft tissueenvelope that surrounds the teeth, disruptingthe occlusion and by creating an intermaxillaryforce.[33,34]

CHANGING THE SOFTTISSUE ENVIRONMENT

The teeth sit in a zone of soft tissue balancebetween the lips and the cheeks on one sideand the tongue on the other. Certain functionalappliance systems, such as the functionregulators developed by Rolf Fränkel, incorporatebuccal and labial shields or pads thatdisplace the lips and cheeks away from theteeth. This allows the dental arches, especiallythe upper, to expand as the force of the softtissues is removed. However, there is no evidence that this type of expansion is any morestable than other more active forms of expansion,especially across the lower inter-caninewidth, which is particularly prone to relapse.Posturing the mandible forward will alsochange the position of the lower lip. Withan increased overjet, the lower lip often restsbehind the upper incisors, proclining themand retroclining the lowers. This is oftenreferred to as a lip trap. By posturing thelower jaw forward, the lower lip moves infront of the upper incisors, freeing the lower incisors to procline and applying a force tothe upper incisors, which retroclinesthem.Following treatment, it is important that this relationship is

maintained, with the lower lipresting in front of the upper incisors creatingan anterior oral seal, because if the upperlip drops back behind them the overjet willincrease.[34-36]

CLASS II EFFECT

Orthodontists routinely pitch one jaw againstthe other when they use inter-maxillary elasticsto help correct antero-posterior problemsand provide anchorage support. Functionalappliances produce a very similar effectthrough the muscles and soft tissues surroundingthe teeth. Many of the activatortypeappliances were specifically designedto be loose in the mouth, activating theelevator and protractor muscles of the jawsto keep the appliance in place. The forcesgenerated were transmitted to the jaws andteeth. As these forces are intermittent, thisforce would be reduced at night and thereforesome of the appliances were designedto open the bite vertically to a much greaterextent than Andresen's orginal activator. Thetheory was that this then enlisted the elasticproperties of the muscles and connective tissuesor 'viscoelastic forces', which would bemaintained even if muscle activity fell off.The appliance was also more likely to stayin place at night. As such, appliances such as the Harvold or Woodside activators openthe bite much further than the freeway spaceand similar changes would be expected fromthe Twin Block appliance.Early research focused on how the posturalcomponent of these appliances affectedactivity of the muscles of mastication, particularlythe lateral pterygoid, the fibres o which run directly into the condylar cartilage.Use of electromyography (EMG) showed hyperactivity of this muscle onprotrusion of the mandible and the conclusionwas that this would result in bony remodeling and growth at the condyle and glenoid fossa. However, while EMG studieshave given equivocal or even contradictoryresults,8 there is no doubt the postural elementof the appliance imparts considerable force between the maxillary and mandibulardentitions. This results in distal tippingand movement of the maxillary teeth andmesial movement of the mandibular teeth,which aids Class II correction. This can be facilitated by introducing faceting intothe acylic of the appliance to guide eruptionof the buccal dentition. Clinically, the dentoalvolar effects are most apparent withproclination of the mandibular and retroclination of the maxillary incisors.[22,23] Thesedental changes are most apparent with fixedfunctional appliances, where rapid tipping ofthe teeth and changes in the occlusal planeare consistently seen due to the full-timedirectional forces.

DO FUNCTIONAL APPLIANCESGROW JAWS?

It has been known since the nineteenth century that bone will remodel and adapt tomechanical loading. This is further supported by cultural practices, such as foot bindingand the of use neck rings, which show that environmental factors can change and mould the skeleton. However, these typesof forces are provided from birth when thegreatest amount of growth is occurring.Therefore, while functional appliances mightbe expected to have some effect on growthof the facial skeleton, this is likely to be arelatively short-term influence during wearof the appliance. However, this has provedto be an attractive and enticing propositionfor both clinicians and patients, even thoughthe evidence that functional appliances cansignificantly influence jaw growth is limited.Animal studies in rodents and primate have shown if the mandible is posturedforward, cellular changes do occur at thecondyle and glenoid fossa, particularly injuveniles and growing animals.[9-11] Thesechanges consist of an increase in mitoticactivity of the prechondroblastic cell layerin the condyle and bony remodeling of theanterior border of the glenoid fossa. However,rodents and primates grow and mature faster than humans which has the effect ofmagnifying these changes. Moreover, these experiments generally consist of convertinga normal occlusion into a malocclusion, as opposed to correcting an underlying existingskeletal discrepancy. These appliances also invariably impose on the animal a treatmentregime that would be difficult for

a human patient to tolerate. Finally, the physiology and anatomy is different, particularly ofrodents, and therefore the direct applicationof any results to humans needs to be donewith caution.Other evidence for the effects of functionalappliances on growth has come fromclinical studies, primarily using cephalometric radiography. Early studies tendedto be retrospective case series reporting on the effects of the appliances. As such, they were susceptible to bias and tended toover-emphasize the positive effects of treatment.1 They did not report on success ratesand often compared patients treated withfunctional appliances with untreated subjectsfrom unrelated historic growth studies.Measurements tended to be taken from lateral cephalograms taken immediately followingfunctional appliance treatment, usingunreliable and convenient cephalometricpoints to measure skeletal change and nottaking account normal expected growth. Itis, therefore, unsurprising that many of theseinvestigations reported that functional appliancescould significantly increase mandibularlength.12Over the last decade, three large randomized clinical trials have been undertaken,two in the USA and one in the UK. These haveshown that initially there is a significantincrease in mandibular length, which can bemeasured cephalometrically in patients whoare treated with a functional appliance, comparedwith controls.[13–15] However, as thesepatients were followed through adolescence,these favorable growth changes were lostand ultimately, patients treated with functionalappliances and those treated withother types of appliances were essentiallythe same.16–18 Critics of these studies havesuggested that they do not represent 'realworld' orthodontics, often carried out in universitydepartments by students less experiencedwith the appliances. However, the UK-based study was carried out in hospital departments by experienced consultants and it came to the same conclusions. Functional appliances did not result in a significantlong-term increase in mandibular length asmeasured cephalometrically. It can be arguedthat the measurements used do not take intoaccount the growth rotations of the mandiblethat occur and have been described bythe implant studies of Björk and thereforeunder estimate mandibular growth.[19] There isalso the wide variation and unpredictabilityin response to the appliances, with a percentageof patients' jaw relationships improvingon their own without treatment which makesinterpretation to a mean difficult. However,combined, these clinical trials have provideddata for well over 300 patients which makesit difficult to ignore their findings.In terms of the effects of different types of appliances, a series of controlled clinicaltrials in the UK have compared Twin Block appliances with other types of functionalappliances, including Bionators, miniblocks,Bass and Dynamax appliances, by systematicallymatching samples by age and genderand targeting treatment at early puberty. Theoutcome was a consistently greater increase in mandibular length with the Twin Block,with much of this length being expressed asan increase in the vertical dimension. Theoverall increased length was clinically significantvertically, especially with a longertreatment period, but limited to additionalforward movement of the chin of around3 mm over a 15-month period,[20-23]However, while the results of this series of studies are promising only the short-term effects of theappliances are presented. In the long term it is unlikely that the average size of anygrowth changes will be clinically importantor significant, echoing the results of thelong-term randomized clinical trials.

CLINICAL USE OFFUNCTIONAL APPLIANCES

TIMING OF TREATMENT

The general dental practitioner plays a very important role in facilitating the successfuluse of functional appliances by referringthe patient at the appropriate time. Anincreased overjet and Class II division 1type of malocclusion may well present inthe primary dentition but more markedly inthe early mixed dentition, with eruption of the permanent incisors. The temptation is therefore to start treatment at this stage with a functional appliance to rapidly reduce theoverjet. However, starting treatment in thepre-adolescent period, while usually

effective, will often necessitate an extendedperiod of retention to allow the permanentdentition to establish itself before a secondcourse of treatment with fixed appliancesto detail the occlusion. [37-40]

FUNCTIONAL BITE

Having decided to correct an increased overjetwith a functional appliance, an importantquestion is whether this should be done inone treatment episode, or through progressive forward posturing of the mandible. Anoverjet of up to 10 mm can theoretically becorrected with a single advancement, butposturing beyond this is more difficult totolerate, so in these circumstances an appliancewill need to be reactivated or a secondappliance used once some overjet reductionhas been achieved. Activator appliancescan be reactivated by sectioning them andadvancing the lingual flanges; Twin Blocksby the addition of acrylic to the block andHerbst or other fixed functional appliancesby added rings or crimpableshims to themale component of the telescope or piston.Some clinicians, however, advocate instead of reducing the overjet in one go, it shouldbe reduced gradually by reactivating theappliance. They claim this will improve toleranceand wear of the appliance while optimizing the effects on growth. [35]

CONCLUSIONS

Despite the lack of evidence that functionalappliances have any clinically significantlasting effect on mandibular growth, they arevery effective appliances for the treatmentof Class II malocclusion and the reductionof an increased overjet. This appears to beachieved through a combination of dentoalveolareffects, alteration of the soft tissueenvironment and the utilization of greatermandibular growth potential compared withthe maxilla, at a point when the patient is actively growing. However, many of theseappliances are difficult to wear and tolerate,which can make compliance difficult.Therefore, treatment is not always universally successful. As such, any potential patient needs to be carefully selected, at an appropriate age and skeletal morphologyand informed of the need for excellent cooperationbefore embarking on what can be very demanding but ultimately very effective and rewarding treatment.[38,41-44]

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