Diplomarbeit

Influence of orofacialmyology therapy on upper intercanine distance

eingereicht von

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Geb.Dat.: 01.02.1988

zur Erlangung des akademischen Grades

Doktor der gesamten Zahnheilkunde

(Dr. med. dent.)

an der

Medizinischen Universität Graz

ausgeführt an der

klinischen Abteilung für Kieferothopädie

an der Universitätsklinik für Zahn-, Mund- und Kieferheilkunde Graz

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Eidesstattliche Erklärung

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Graz, am 13.12.2013 *Christoph Moschik*

Preface

This research is the final proof of competence for obtaining the doctors degree in dentistry (Dr. med. dent.) from the Medical University of Graz, Austria.

The research was a remittance work given by the Coulson Institute of Orofacial Myology and has been supervised by the Medical University of Graz, department for orthodontics under the authority of Ass. Prof. Dr. Margit Pichelmayer and the Coulson Institute of Orofacial Myology, the external principal.

Data collection has been executed in the United States on site of the Coulson Institute of Orofacial Myology in Denver, Colorado. This research focuses on the influence of facial muscle exercises and changes of the muscle equilibrium on the intercanine distance.

Acknowledgement

I especially thank Ass. Prof. Dr. Margit Pichelmayer for supporting my interest into functional orthodontics as well as facial myology. It was a pleasure to have many open-minded discussions, otherwise this paper would not have been possible.
Also I want to thank Mrs. Sandra Coulson, for giving me the possibility to join the Institute of Orofacial Myology in Denver, watch the clinical work, providing the data and spending the time explaining many details of orofacialmyology and connections to the rest of the body.

Further thanks are towards my family, for always supporting me and giving me the chance to fully concentrate onto my studies.

Thanks also go to Mrs. Dipl.Ing Mischak for supporting me with the statistical calculations and all the individuals contributing directly or indirectly to this paper.

Zusammenfassung

Ziel: Ziel dieser Arbeit ist es den Zusammenhang von fazialen Muskelübungen, inklusive dem Positionieren der Zunge am harten Gaumen und Veränderungen im Eckzahnabstand des Oberkiefers bei ausgewachsenen Patienten zu ermitteln.

Studiendesign: Retrospektive Studie, Auftragsarbeit des Coulson Institute of Orofacial Myology.

Untersuchungsklientel: 141 Frauen und Männer über dem 18.Lebensjahr ohne simultaner kieferorthopädischen Behandlung.

Material und Methoden: Die Arbeit erfolgte im Auftrag des Coulson Institute of Orofacial Myology und hatte ein retrospektives Studiendesign.
Alle Patienten haben sich mindestens 8 Monate lang einer myofunktionellen Therapie für das Gesicht untersagt. Die Therapie bestand aus verschiedenen Muskelübungen für die Lippen, Wangen, Zunge und Körperhaltung. Zusätzlich platzierten die Patienten zur Unterstützung der Schluckfunktion drei Mal täglich ein kleines Gelatineblättchen am harten Gaumen. In jeder Behandlungssitzung wurden die Philtrumslänge, der Eckzahnabstand und der Overjet gemessen.

Resultate: nach 8 Sitzungen hat sich der Eckzahnabstand um durchschnittlich 3.2mm vergrößert, während die Philtrumlänge um 5.4mm zunahm und sich der Overjet im Durchschnitt um 1.2mm verringerte.

Konklusion: Die Ergebnisse dieser Studie zeigen, dass sich die Zahnposition im Oberkiefer durch Muskelübungen selbst in ausgewachsenen Fällen noch verändern lässt. Dies impliziert die unterstützende Wirkung von gezielten Muskelübungen für die kieferorthopädische Therapie.

Abstract

Objective: To investigate the correlation between myofunctional exercises, including repositioning the tongue onto the palate and changes in intercanine distance of the upper jaw in non-growing patients.

Design: Retrospective study, remittance work of the Coulson Institute of Orofacial Myology.

Subjects: 141 women and men above age 18, with no simultaneous orthodontic therapy.

Material and Methods: This is a retrospective study and was a remittance work of the Coulson Institute of Orofacial Myology.
All subjects have participated myofunctional therapy session for at least 8 month. The training consisted of various muscle exercises for the lips, cheeks, tongue and posture. Additionally the patients put a small dissolvable gelatine pad onto the palate three times a day to assist swallowing function. Throughout therapy the length of the philtrum, intercanine distance and overjet were measured.

Results: After 8 sessions the average intercanine distance did increase by 3.2mm, the philtrum elongated by 5.4mm and the overjet decreased by 1.2mm.

Conclusion: The results indicate that tooth position can be changed by muscle therapy, even in non-growing subjects. This implies that muscle training can be a highly supportive therapy for orthodontic treatment.

Contents

1 Introduction

1.1 The Intercanine Distance

The Intercanine distance is a transverse measurement of the dentition at its most important position for occlusal function, namely the canines.
Skeletal, alveolar and dental width of the jaw is determined by two important factors.

a) genetics
b) function

These two factors correlate with the overall body growth factors and are responsible for the morphologic development. While the genetic component currently cannot be influenced or controlled through therapy, it is possible to manipulate the function. As function is the second important factor to form matter in the sense of biological and medical terms, it is a logical consequence to design and apply therapy methods to exert influence on the morphology indirectly.

1.2 Terminology and general considerations

The noun “function“ is described as “a thing dependent on another factor or factors“ by the Oxford dictionary.
The function of the stomatognathic system involves the interaction of all participating tissues as teeth, jaws, temporomandibular joint, muscles and the oral cavity. This concludes that the function of the stomatognathic system is composed of masticatory, phonetic and physiognomic tasks, working together forming a “morphological and functional unit”.

Eugnathia results when morphology and function are within balance and within the norms. In case of aberrance from the norm, “dysgnathia”, “dysalveolarism” or “malocclusion” and dysfunction occur, it is of high importance to understand, how each of these factors influences the other. Orofacial dysfunction can increase the severity of malocclusion, and vice versa (1) (2).

At the beginning of the 20th century, Dr. Edward Angle stated that the field of orthodontics is only at the beginning to understand what influence the cheeks, tongue and lips have onto malocclusion and how difficult it is to work with them. Furthermore he stated that there was no chance to have long term success in therapy without correcting the malfunction of this system.
It is utterly important to recognize and diagnose a certain problem before being able to correct it (3).
Additionally Moyers claimed that therapy is needed to address the root of the problem directly as well as treat the causes of malocclusion instead of just straightening teeth (4).
Nowadays the importance of interdisciplinary cooperation has become more vital and besides orthodontists, also myofunctional therapists and logopaedics, specialised physical therapists, ear-nose-throat specialists, and paediatricians are concerned about the topic of orofacial function.

Each one of these disciplines ought to influence the facial morphology of the patient by changing the function towards an eugnatic norm. This interdisciplinary therapy can be classified as follows:

Discipline	Type of therapy	Devices	Therapist
Orthotropic	no orthodontic appliances, muscle exercises, correction of function	Few devices, young age, influence on jaw	Functional therapists
Orthopaedic	Orthodontic appliances influencing growth	Removable appliances, age between 7-14	Orthodontist
Orthodontic	Appliances influencing dental position	More devices, increased age, less jaw influence	Orthodontist

Table 1: Disciplines and its according type of therapy, devices used and specialised therapist

Orthotropic: This treatment targets the growth of the face and jaws as well as trying to give the body the chance to self-correct. Diagnosis consists of checking the patient for abnormal function, like thumb sucking or mouth breathing. The therapy aims to enable normal swallowing, proper breathing through the nose with a closed mouth and to stop any habits, like thumb sucking or lip chewing. To maximize the effect of this therapy, it is best applied in young children. The earlier therapy is applied and a habit is broken, the more chances there are for the body to return to a normal development.

Orthopaedic: If jaw discrepancies are already apparent, either due to excessive or restrictive bone growth, this type of therapy can be applied. It consists of intraoral or extraoral appliances that apply a high force on the maxillary or mandibular bone and thus try to either encourage or decrease growth.

Orthodontic: This phase of the treatment describes the adjustment of the occlusion by moving and aligning the teeth. As in this stage the jaws should be already eugnathic, these techniques are only applied after orthotropics and orthopaedics are finished.

Summarizing these techniques, it can be said that orthotropic therapy should be applied roughly between age 0 and 8, at the beginning of the change to the second dentition. This is followed by orthopaedic therapy, which should be executed during the early phase of the second dentition, which correlates with the age of 9 until all permanent teeth are exfoliated. By the time the dentition is fully developed, orthodontic therapy is indicated.
As age progresses and growth slowly ceases, the possibility to influence jaw growth decreases. While the impact on jaw growth subsides, teeth movements are possible at all times – this is the standard opinion of worldwide orthodontics throughout the last five decades. New research on orthotropic therapy, more specifically myotherapy, states it is a fact that there is no age limit for its application.

This consideration is absolutely correct, as orofacial dysfunctions are not solely limited to children, but can also occur in adults; hence treatment should be applied whenever improper function occurs.
What causes orofacial dysfunction? As the topic of this work is the analysis of the intercanine width, in the following the correlation between dysfunction and the influence on the frontal area of the dentition will be primarily described.

1.3 Orofacial function and dysfunction

1.3.1 Lips and their muscle system

Correct lip function: Lips stay in contact without pressure while resting and swallowing. If one swallows correctly, no changes in the outer facial muscles are apparent.

Main affected muscles: The premise for properly closed lips is the balance of all facial muscles. An equal tonus is especially required of the following muscles:

- M. orbicularis oris
- M. levator labii superiores
- M. levator labii superioris alaeque nasi
- M. levator labii superioris anguli oris
- M. risorius
- M. zygomaticus minor
- M. zygomaticus major
- M. masseter
- M. pterygoideus medialis
- M. temporalis

False lip rest posture: It often happens that lips are slightly opened while resting. In case of mouth breathing, the lower jaw drops and separates the lips even more. In case of dental malocclusion of the front teeth, the incisors can be visible or even bite on the lower lip.

Imbalanced lip tonus: A short upper lip and a thicker, outward-rolled, red-coloured lower lip are apparent.
As the mouth opens, the tonus in the lips changes – the upper part of the orbicular muscle is not used as much as it should be and shortens as a result. The lower part rolls outwards and appears to be enlarged. Due to the broken lip seal, saliva drops and moistens the lips resulting in its irritation. Dry and chapped lips are often accompanying signs of an open-mouth rest posture and a compensatory lip-licking can be observed in many of these patients.
It often occurs that an open-mouth-rest posture is a result of a blocked nasal airway. In this case a professional opinion of an ENT-doctor is highly recommended.

False lip function during swallowing: If the lips have problems to maintain the lip seal, compensatory movements are required to enable swallowing. There are three possibilities to do so:

1)The tongue is pressed forward against the teeth to seal the inner side of the incisors.
2)Lips are pressed together to establish low-pressure while swallowing.
3)A combination of these two principles is possible.

1.3.2 Correct tongue rest position:

- To simplify this description, it is convenient to divide the tongue into thirds. The tip of the tongue, being the first third, should be in laminar contact with the palate, slightly behind the front teeth (5). The rest of the tongue is relaxed.
- Lips are closed
- Nasal breathing
- Mentalis muscle is relaxed
- Teeth are at physiologic rest position, about 2mm away from each other, which is the so called “freeway space”.

Proper swallowing:

- The first third of the tongue stays in the same position as during rest, but is pressed against the palate.
- Lips are closed
- Teeth are in contact
- The middle of the tongue (second third) is sucked to the palate while the posterior part of the tongue (third part) is pressed against the soft palate to close the naso-pharynx and the swallowing reflex is triggered.
- Mentalis muscle is relaxed

Involved muscles:

Extrinsic tongue-muscles: these muscles change the position of the tongue

- M. genioglossus
- M. hyoglossus
- M. styloglossus

These Muscles adjust the hyoid bone

- M. digastricus
- M. mylohyoideus
- M. geniohyoideus
- M. stylohyoideus

Intrinsic tongue muscles: these muscles change the form of the tongue

- M. longitudinalis superior
- M. longitudinalis inferior
- M. transversus linguae
- M. verticalis linguae

False tongue rest position:

Depending on the malformation of the bone and the malocclusion or muscular problems, different types of improper tongue positions can be described. Most common are the following:

- Tongue in between the front teeth or in an occlusal gap
- Tongue pushing against the front teeth or into an occlusal gap
- A combination of the two points above

The tongue is laid or pushed against the teeth or fills up occlusal divergences.

Tonus of the tongue

Frequently, the tonus of the tongue is unequally distributed, which can result in strong borders of the tongue and a weak center. When the tongue presses while swallowing, the edges can appear to be red and impressions of the teeth might be visible. A tongue that appears to be enlarged is often just atonic. Real macroglossia is very rare and needs proper diagnosis.

Frenulum

The frenulum under the tongue can be shortened and restricts the movements of the tongue. In some cases, this can prohibit the tongue from touching the palate during rest position. A variety of stretching exercises can elongate the frenulum. If this does not help, a small surgical procedure, either frenectomy or frenotomy, can be done.
In case the frenulum grows into the tip of the tongue, which is called ankyloglossia, surgery is obligatory to acquire a proper tongue function (6).

False swallowing

The front of the tongue pushes against or in between the teeth, while the middle section of the tongue does not touch the palate. This is quite the same position as while resting. The tongue is not able to process foods, fluids or saliva properly and compensatory actions of the facial and throat muscles become visible. Many times

the head is postured forward to improve pharyngeal space and assist the swallow (7).

Speech

Speech is a complex process and formed by releasing air over the vocal cords and by a fine articulation of the tongue. Hence there are many ways speech can be affected by orofacial myofunctional problems. Most common is the sigmatismus addentalis, interdentalis or lateralis, which is a lisp on the vocal “s”.
To form good acoustics, the combination of proper body posture, breathing and muscle activity is mandatory.
There is a correlation between articulation problems and malocclusion (8,9) but it varies a lot between individuals (10).
Oliver and Evans also found that “speakers with noticeable articulatory defects showed a tendency toward smaller oral dimensions than normal articulators”. Subjects who participated in this study had an average upper intercanine width of 24.6mm (11) An association between a small oral cavity and faulty speech is supported by Fymbo (12) and Lubit (13).
Still it has to be mentioned, that the mechanism behind speech and dental position needs to be the subject of further investigations (14).

1.3.3 The mentalis muscle

The mentalis muscle determines the chin appearance, assisting in moving the lower lip outwards and pushing the lower lip upwards.
In case of open-mouth-rest posture and a shortened upper lip, this muscle assists in moving the lower lip upwards to obtain a lip seal while swallowing. This continued movement results in a hyperactivity of the mentalis muscle and can be seen on the chin due to an increased mentolabial fold.
The mentalis muscle might not be able to directly influence the intercanine width, but is still important to position the lower lip and keeping the balance in the muscle system. The lip resting position helps to maintain the occlusion (15). A link between an increased activity of the mentalis muscle and mouth breathing was

stated by Dutra et. al (16). Also an increased mentalis muscle activity can be observed in the presence of sucking habits leading to malocclusions (17).

1.3.4 Facial and chewing muscles

In case of a myofunctional disturbance the mimic muscles are not well used. All the muscles of the viscerocranium appear to be restricted in their movements and the face has a bad muscular expression during speech (1).
At the same time the chewing muscles are weak, as they are not used properly. The jaw is held in a downward position, instead of the proper physiologic resting position.
Furthermore a correlation between the masseter muscle thickness and the maxillary arch width exists (18). In general it can be assumed that craniofacial width is linked with the cross-sectional areas or thickness of the masticatory muscles (19-21).
By defining the maxillary transverse bone dimension, masticatory muscles can also influence the upper intercanine width.

1.3.5 The body muscular system

In most cases orofacial malfunction and disharmony are linked to body posture problems (22).

- Neck posture: Generally, the neck is not stretched and the head is tilted backwards to free the airway. This position is bad for the lip seal, tongue position and swallow.
- Back: To keep the eyes pointing forward, the back has to compensate for the head inclination by forming a hyperlordosis of the upper cervicals and a hypokyphosis of the lower back. At the same time the abdominal and spine muscles are weak and cannot support the body properly.
- Pelvis: To compensate for the hyperlordosis and kyphosis of the back, the pelvis tilts forward when sitting and backwards when standing.

It is a difficult task to determine the beginning of this posture-chain and it has to be judged individually. A combination of physical therapy and orofacial myology training is highly recommended to address the deficiencies most effectively (1).

A significant correlation between body posture and mouth-breathing is given by Conti et al (23). and proving general knowledge that mouth breathers do have a smaller intercanine width (24).

Korbmacher et al. also found a significant correlation between weak body posture and all kinds of orofacial myofunctional variables. “A blockade of the iliac spine correlated with persistent habits, articulation disorders and tongue dysfunction, whereas functional asymmetry of the upper cervical spine correlated significantly with incompetent lips” (22).

Furthermore body posture is interlinked with occlusion and changes in one system results in adaption of the other bidirectionally. (Fig.1)

A Class I occlusion supports a balanced spine position and physiologic expression of the kyphosis and lordosis.

In case of a dental Class II occlusion many times the lower jaw is positioned backwards and the head is hold more forward at the same time. This results in a compensatory bending of the thoracic spine and flection in the pelvis.

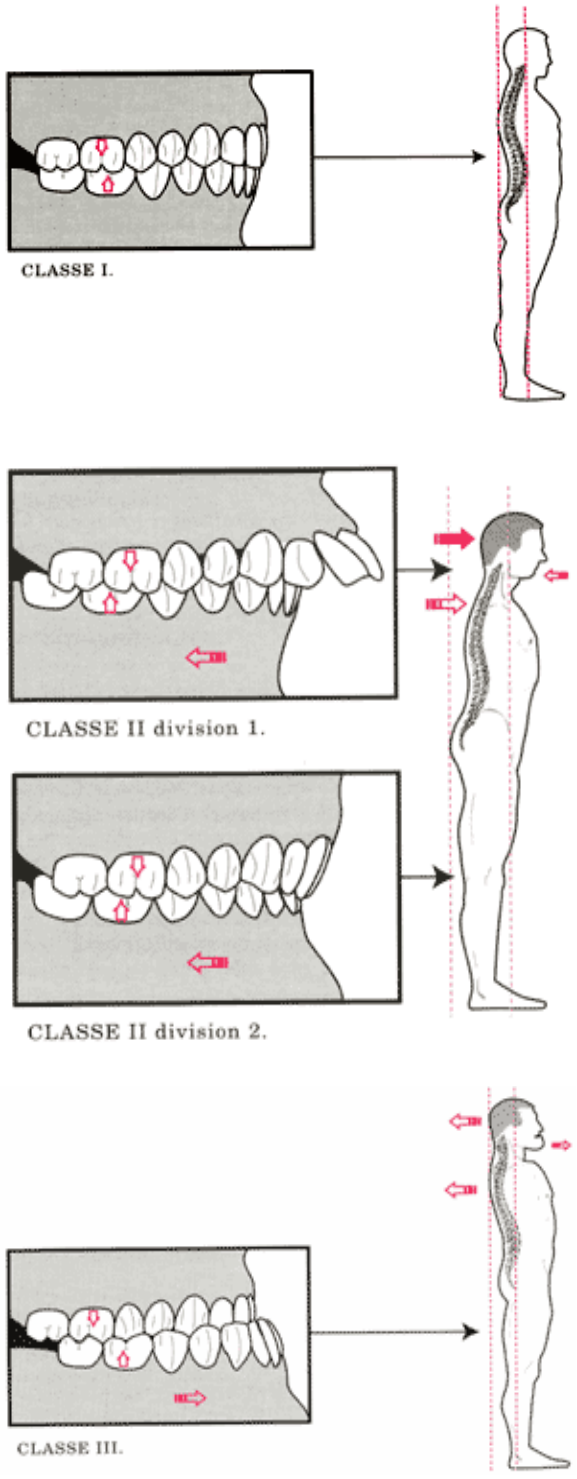

Fig. 1: The correlation between malocclusion and body posture as it is stated by Bricot

In contrary is the head of a Class III malocclusion positioned more backwards, flattening the curves of the spine and tilting the pelvis anterior (25).

1.3.6 Psyche

The body posture is highly interlinked to the mind. An atonic body posture is on many occasions connected to a decreased concentration, cognition, motivation and receptivity.

Smith at el. found a correlation between back muscle endurance and psychological variables. Adolescents with a lowered self-perception and behavioural problems had a decreased back muscle endurance (26).

A change in posture might then lead to an influence on the stomatognathic system and change in tongue posture, which then influences upper intercanine width.

Furthermore it is known, that emotional stress can lead to oral habits (27), causing changes in tooth position or shifting the occlusal “equilibrium” (28). Severe malocclusions themselves can have a negative impact on social, emotional and functional aspects, reducing quality of life of children between age 8-10 (29,30).

1.3.7 Breathing / breathing muscles / diaphragm

A normal breathing pattern is important for an overall good physiology and health.

In general it is favourable to breathe through the nose.

This type of breathing should be maintained throughout all day, breathing specialists even claim that it would be an advantage to keep nasal breathing during exercise. Compared to mouth breathing, nasal breathing has the advantage of moisturizing and warming the air, filtering and decreasing the bacterial load.

In case the nasal airway is obstructed, either due to enlarged adenoids or a deviated septum, the breathing pattern is changed to mouth breathing to ensure oxygenation of the blood. To be able to breathe through the mouth sufficiently, the lip seal is broken and the lips open. At the same time the mandibular tongue position is lowered to create a large passage for the air. In case the adenoids are enlarged, the head posture is moved forward, which increases the oro- and hypopharyngeal space, facilitating breathing. To keep the forward-head posture

balanced, the spine increases the lordosis of the cervical and lumbar area and the kyphosis of the upper back and the pelvic part. The pelvis itself compensates with a forward rotation. The overall body posture becomes compromised (Fig.2).

The influence on the intercanine width is linked to the tongue position change. When healthy, the force of the tongue and the cheeks is opposed and the permanent stimulation of the palate by the tongue leads to an increase of the maxillary bone in the transverse direction. As the tongue is lowered, this stimulating force is removed and the pressure of the buccinator muscles hinders a transverse expansion of the palate. As the intercanine width is highly dependent on the maxillary transverse size, a narrow palate correlates with a decreased intercanine width. As the lower canines are usually on the inside of the upper arch, they become restricted as well, increasing crowding of the lower front teeth. Myser et al. reported increased postretention malalignment of the lower front correlating to anterior arch perimeter, intercanine width and arch from. Narrower arch forms

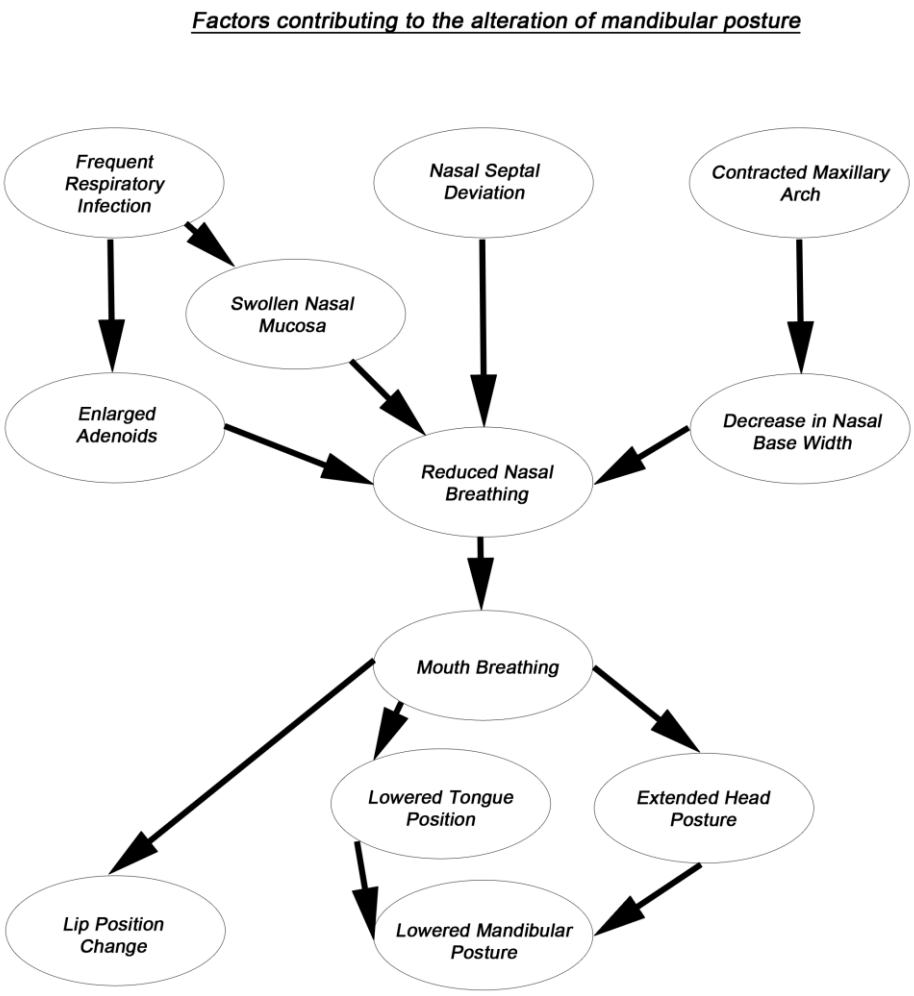

Fig. 2: Reduced nasal breathing leads to mouth breathing, changes in tongue and lip rest position and a lowered mandibular posture.

are more likely to show post-treatment misalignment changes (31).

1.4 Reasons for myofunctional Disorders

1.4.1 Myofunctional dysfunction due to imbalances

The muscle system of the face is highly interlinked and – compared to the rest of the body – it is unique as some facial muscles insert into other muscles and fascia, not always into the bone. Hence the position of the muscles is dependent on other muscle positions and tension, dysfunction can occur if one or more muscles have to execute compensatory movements.

For example, the orbicularis oris muscle has no direct bone connection at all and can be seen as a muscular disc freely moveable in space. To position it properly many muscles insert into the borders and establish an equilibrium holding the orbicularis muscle in position without any effort (Fig.3).

This equilibrium can be disturbed if any of the linked muscles does not function properly or has to maintain a non-physiologic position. In case of an open-mouth rest posture, the lips are not in contact and the upper lip-length shortens. If a swallow is now executed, the lower lip has to be pushed upwards by the mentalis muscle to establish a lip seal. This movement of the mentalis muscle influences the rest of the other muscles, which try to compensate for the movement. As a result abnormal tension can be observed throughout the facial muscles.

In case several muscles are non-functional, the compensation movements even multiply. This can be observed frequently in case of open-mouth rest posture, as described above, in combination with the tongue pressing against the front teeth while swallowing (32). In these cases there is not only tension throughout the face, but also the coerced forward position of the tongue leads to forced movement of the supra- and infrahyoidal musculature. In these cases swallowing requires a high effort. Forces on the dentoalveolar system are not applied in a physiologic way anymore.

Again, due to the lower tongue position in combination with higher muscular tension from the facial muscles, the maxillary bone becomes constricted and the intercanine width is affected. At the same time masticatory muscles are stretched and weakened, due to the open-mouth rest posture. As a consequence, the lower jaw develops a high angle and leads to a long-face appearance.

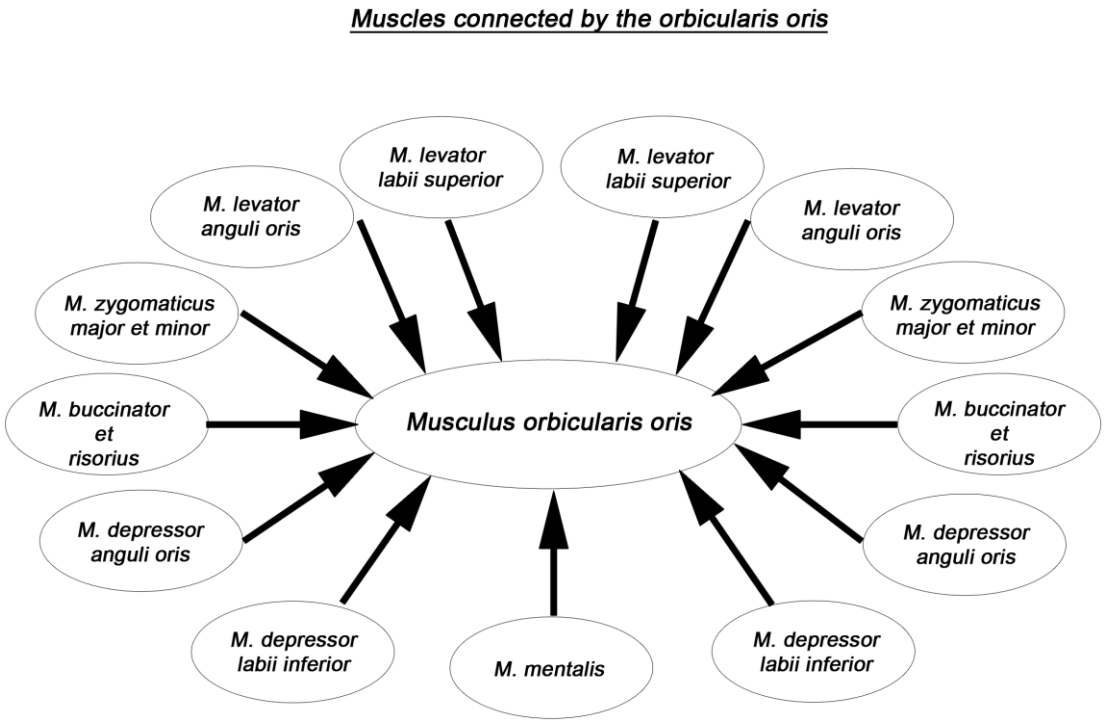

Fig. 3: Muscles connected to and via the orbicularis oris muscle. If any of these muscles is out of balance, the others have to compensate to ensure function of the system.

1.4.2 Disorders due to atypical muscle structures and associated metabolism

Disturbances during embryonic development: Facial muscles are not properly formed or built while the embryo developed.

Complications during birth: If a short oxygendeficiency appears, minimal cerebral dystonia might appear and can influence the capacity to control muscles. Under these circumstances, also facial muscles can be affected.

Deep sensory insufficiency: This occurs when having problems to coordinate muscles or if there is a restrictive ability to move these. In such a case, the tongue might not be able to fulfil necessary movements with acquired accuracy. The reason is the missing feedback from the sensory system of the body.

Vestibular insufficiency: If the vestibular organ is working insufficiently, body posture will be affected and a decreased tonus of the musculature might also affect the facial muscles. This can be a reason for a restricted capability of mimic and facial expressions. Further serial dysfunction may be apparent, which means that muscles cannot change between several positions quickly or holding tension for a period of time. The changes of the tongue between speaking movements and rest position would be such a series.

1.4.3 Influence on the jaws

Studies have reported a correlation between the tongue resting position and the form of the palate. If the tongue does not rest on the palate a high vault develops, occasionally narrowing the base of the nose and constricting nasal airflow (33).

1.4.4 Cross-bite

If the upper jaw becomes too narrow, a crossbite can develop. This means, that the upper teeth have a stronger lingual position compared to the lower ones. Depending on the severity, this can either be a single tooth, one side or even both sides.
A correlation between a posterior crossbite and a constricted maxillary arch is well known (34), non-nutrive sucking habits of a longer duration are found to be one of the major causes of open bites and posterior crossbites (35).
In this way also the intercanine width can be affected.

1.4.5 Open bite

If the tongue pushes against the front teeth at rest, they can start to flare and open the bite.
Other causes of open bites can be habits (35) like thumb or pacifier sucking (36). In this case a primarily non-tongue-related open bite can lead to a malfunction of the tongue. The tongue fills up the created space to maintain it or even worsens the situation.

In a study by Verrastro et al. it was found, that in the case of an anterior open bite related to pacifier sucking, a significantly greater overjet and smaller maxillary intercanine width existed (37).

1.4.6 Mandibular protrusion

The mandibular jaw is relatively too large for the upper arch, either due to a too small maxilla or an enlarged mandibula. In many prognathic cases, the tongue rests in a lower position, which could be a cause of the excessive growth (33).
This lowered tongue position is associated significantly with the dentoalveolar characteristics of the maxilla and mandible, presenting a smaller upper intercanine width (38).

1.5 Orthotropic therapy in detail

Orthotropic therapy is based on the assumption that these changes appear due to improper usage of the oral-musculature system. If an adequate function is restored, the body will adapt and the facial growth changes according to it. This theory goes along with the Functional Matrix Theory (39) which claims that the whole stomatognathic system develops, aside from genetics, along with the demanding functions and the tasks that are given to it.
Orthotropic therapy mainly focuses on the treatment of the muscular system, by levelling imbalances and usage of strength training.
A varying amount of exercises are used in the clinic of Sandra Coulson, individually adjusted to the patient needs with many graduations. In general, they are focused on changing the facial muscles using isotonic contractions, increasing the movement possibility due to stretching or becoming more aware of the muscle system by doing movement exercises. For a better understanding of the treatment, exercises used in the therapy session are listed below. Names of these exercises are according to Sandra Coulson.

1.5.1 Tongue restposture training

The therapy is based on the positioning of a specific “pad” onto the palate.
The “pad” is round with a diameter of 5 mm and is cut out of a specific gelatine plate.

The gelatine ‘spot’ used is made from a basic material. This is a “Stomahesive Skin Barrier” manufactured by ConvaTec, A Bristol-Myers Squibb Co. It is soft, pliable light tan adhesive wafer with a plastic film backing on one side and a protective removable silicone release paper on the other side (Fig.4).
It consists of a Polyethylene-film, Silicone release paper, Sodium carboxymethyl cellulose (40), Pectin (41), Gelatin and Polyisobutylene (42-44). All of these materials are also used in food industry, either as ingredients for food or as packaging.

Fig. 4: picture of the Stomahesive ® Skin Barrier in the original packaging

The pad is cut with a one-whole-punch out of the basic material. The Polyethylene film on the front side is removed as well as the silicone release paper on the backside. The patient’s right thumb is then slightly moistened with water and the pad placed on it.

Then the palate is dried with a tissue or handkerchief and the patient places the gelatine pad approximately 5mm behind the upper incisors on the palate in the mid of the rugae by simply touching the palate with the pad on the right thumb. Slight pressure against the palate is sufficient to fix the pad on the palate-gum

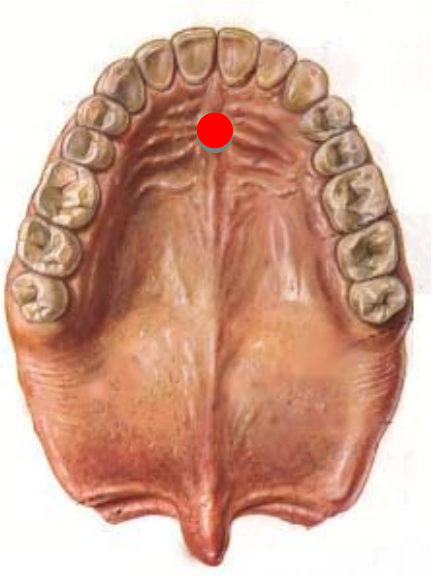

Fig.5: Position oft he gelatine pad on the palate

This position is called the “spot“ (Fig.5). For some time the pad is resistant to saliva or mechanical irrigation as it appears during drinking and touching with the tongue. After about 3-4 hours the gelatine-pad dissolves.
The patients replace the pad 3 times a day, after breakfast, after lunch and before going to bed.

1.5.2 Tongue exercises

Tip Pops: The tip of the tongue is placed on the palate, at the spot, and suction is produced. Then the teeth are opened slightly with a big, wide smile and suction is relieved with a “pop”-sound without letting the tongue touch the bottom of the mouth.

Taco Blows: The tongue is stretched out of the mouth and the sides are rolled up, shaping a Taco-like form. Then air is sucked in and blown out as hard as possible.

Penny Stick Hold: Coins are taped to a wooden spatula and the tongue is rolled around the other end. Then the

tongue is pushed forward out of the mouth, holding the spatula horizontal for approximately 20 seconds. As many coins as possible are added.

Palate Scrapes: The mouth is opened wide and the tip of the tongue is placed on the spot. Then the tip of the tongue scrapes back towards the throat, while the mouth stays open.

Tooth Cleaners: The lips are closed and the tip of the tongue is placed between the teeth and the lips. Then it moves in a circle around the teeth, while the lips stay closed. There should be no jaw movements.

Suction Stretch Hold: The tip of the tongue is suctioned on the spot and the mouth is opened as wide as possible. The tongue-tip should stay in contact with the spot.

Tongue-tip Sit Ups: The mouth is opened and tongue stretched straight out. Then the tip of the tongue is raised and lowered, without moving the jaw.

Fat-Skinnies: The tongue is stretched out straight and muscles are contracted in the way that the tongue becomes skinny. Then all muscles are relaxed to make the tongue appear fat.

Suction Stretch Hold Swallow: Tongue is suctioned onto the palate and mouth is opened as wide as possible. Then the mouth is closed, the patient clenches one’s teeth, smiles and swallows.

1.5.3 Lip exercises

Lip pops: The lips are rolled over the teeth and pressed together with a slight suction. Then the mouth opens slightly and making a loud “pop” sound.

Granny Surprise Face: The lips are rolled over the teeth, form an “O” by opening the mouth wide and eyebrows are raised as much as possible. Position is held for 20 seconds.

Button Pull: A button is fixed onto a string and then positioned between lips and teeth. Then the string is pulled to the left, straight and to the right, as strong as possible, while the lips are pressed to stay together. The button should not move to the outside of the lips.

Straw drink: A cup is filled with water and a long straw is placed in it. The patient bites together and places the straw in front of the teeth, puckers the lips and sucks in the water. Teeth stay closed.

Bottle hold: A bottle is filled with water and a string with a button is attached to its neck. The teeth are closed and the button is placed in front of them behind the lips. Then the lips are pressed together and the patient lifts the bottle of the ground, while standing bent over in a squat-like position.

Turtle lips: The cheeks are sucked in between the teeth while the upper lip is sucked downwards and the eyebrows are raised as far as possible. This is held for approximately 20 seconds.

Cork Pulls: A cork is placed in front of the teeth, the lips close about it and the cheeks are sucked in. Then the cork is pulled out with a fast movement in a way that a “pop” sound appears.

Turtle Lip Pops: The cheeks are sucked in, the upper lip is pulled down and the eyebrows are raised. Then the jaw is slowly opened, until a “pop” sound is produced.

Air Trap: The teeth are closed while the lips are pressed together firmly and then air is puffed into the cheeks until the lip-seal is broken.

Cotton Roll: A cotton roll is placed between the front teeth and the upper lip in the reflection area and remains there for 30min.

1.5.4 Posture exercises

Wall Stand: The patient stands with his back to a wall and raises the arms in an angle of 90 degrees. The back of the head, shoulders, hands, hips and heels should be in contact with the wall. The position is held for 30 seconds.

Wall Slide: The back of the head, shoulders, hands, hips and heels are in contact with a wall, while the arms are raised in a 90-degree angle. Then the knees are bent and the patient slides up and down the wall.

Corner Wall Stand: The patient stands facing a corner and raises his hands in a 90-degree angle, keeping hands and wrists in contact with the wall. Then the body is moved slowly towards the wall and pushed back again.

Corner Push-Ups: The patient faces a corner, places his hands on the walls and makes a push-up movement.

Doorway-Fly-Through: The patient stands 50cm away from an open door, and holds on to the walls beside the door with arms bent in a 90-degree angle. Then he leans forward, while keeping the head up, until a stretching can be felt. This position is held for approximately 20 seconds.

2 Material and Methods

2.1 Patients

The patient population of 141 was fully treated by Sandra Coulson between 1998 and 2012. A requirement of a minimum of 4 and a maximum of 10 sessions without accompanied orthodontic therapy had to be met. Therapy solely consisted of the facial muscle exercises as described above and putting the already mentioned gelatine spot about 5mm behind the upper incisors onto the palate three times a day.

2.2 Patient Raising

Patient history files were manually searched at Sandra Coulson's office. A pool of thousands of patient files was available and the search was done by chronically going backwards and any patient who fulfilled the criteria was chosen. The selection process stopped with files from 1998, as the recordings were not as meticulous in the older ones. The files were then manually scanned and valuable data typed into an excel sheet.

Selection criteria:

- age 18+
- no orthodontic treatment accompanying Sandra Coulson's treatment period
- minimum of 4 therapy sessions, maximum of 10
- consecutive recordings of the measurements (intercanine width)
- stomahesive pad placed on the palate for whole therapy time

2.3 Intercanine Measurements

Sandra Coulson herself measured the intercanine distance (Fig.6) with a standard calliper in between the tips of the upper canines at each visit of the patient intraorally, which is as reliable as measurements on study casts (45). This parameter was chosen, because the canine-distance is more convenient to measure during the daily clinic routine of an orofacial myologist rather than the intermolar distance. Yet it gives significant information about the dental arch development (46,47).

Fig. 6: Intercanine distance

2.4 Statistical Methods

The data was listed on an excel sheet, with columns according to the sessions and subdivisions respective to the measured values. To inquire the influence of time and sex a general linear model with repeated measurements was performed. The calculation was done with the SPSS V.20 software (IBM©) and Microsoft® Excel 2010.

3 Results

3.1 Patients

This retrospective study consists of 141 patients, which fulfils the former mentioned criteria.
110 of the patients were female, 31 were male and all patients reached at least the age of 18. Average age was 43.4 years, with a minimum of 18 years and a maximum of 78 years.

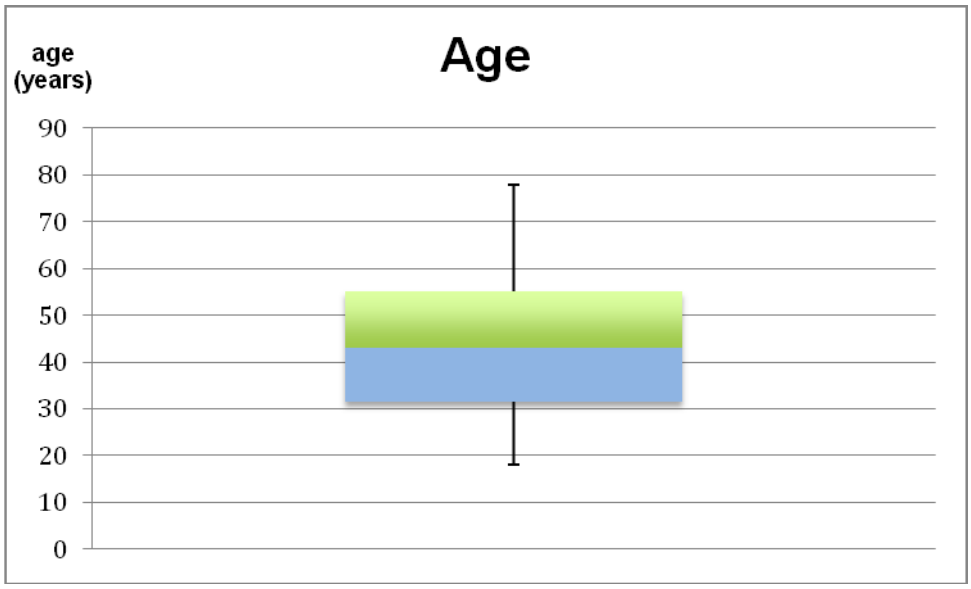

Fig. 7: age distribution of patients included in the study

3.2 Sessions

In average 7.4 sessions were held with the patients, while the average time between each session was roughly one month. The amount of participants dropped after the 8th session rapidly and therefore session 9 and 10 were excluded.

	Participants	Percentage
Session 1	141	100.00%
Session 2	141	100.00%
Session 3	141	100.00%
Session 4	141	100.00%
Session 5	137	97.16%
Session 6	131	92.91%
Session 7	116	82.27%
Session 8	98	69.50%
Session 9	**85**	**60.28%**
Session 10	**73**	**51.77%**

Table 2: number of patients at each session; session 9 and 10 were excluded due to insignificancy

	days
Session 1-2	19
Session 2-3	25
Session 3-4	27
Session 4-5	35
Session 5-6	25
Session 6-7	33
Session 7-8	48

Table 3: average days between each session

3.3 High Vault

In 20.6% of the patient cases, there was no data available if they had a high-vault or not. Still 75.9% patients were classified as high-vault and only 3.5% patients were classified either as normal or broad vault.

	Quantity	Percentage
n.a.d.	29	20.6%
+	107	75.9%
-	5	3.5%

Table 4: number of patients with high vault;
n.a.d. = no available data
\+ = high vault
\- = no high vault

3.4 Intercanine Width

After all the change of intercanine width was highly significant during treatment ($p<0.001$). There is no significant difference between female and male ($p=0.981$)

	Collective		female		male	
	Arithmetic average	Standard deviation	Arithmetic average	Standard deviation	Arithmetic average	Standard deviation
Session 1	33.3	2.7	33.0	2.6	34.3	2.7
Session 2	34.5	2.2	34.3	2.1	35.3	2.1
Session 3	35.0	1.8	34.8	1.6	35.7	2.2
Session 4	35.4	1.7	35.3	1.5	35.8	2.1
Session 5	36.0	1.5	35.8	1.4	36.3	1.8
Session 6	36.0	1.9	35.7	2.0	36.7	1.4
Session 7	36.2	1.9	36.1	1.5	36.5	2.7
Session 8	36.5	1.5	36.4	1.5	37.0	1.6

Table 5: development of intercanine width according to the sessions

Within the first 5 sessions of the therapy a rapid increase of inter-canine width is achieved. This was in average 2.7mm, or 84,4% of the overall widening.
After 8 therapy sessions or the approximate time of 8 months the difference of 3.2mm was reached.

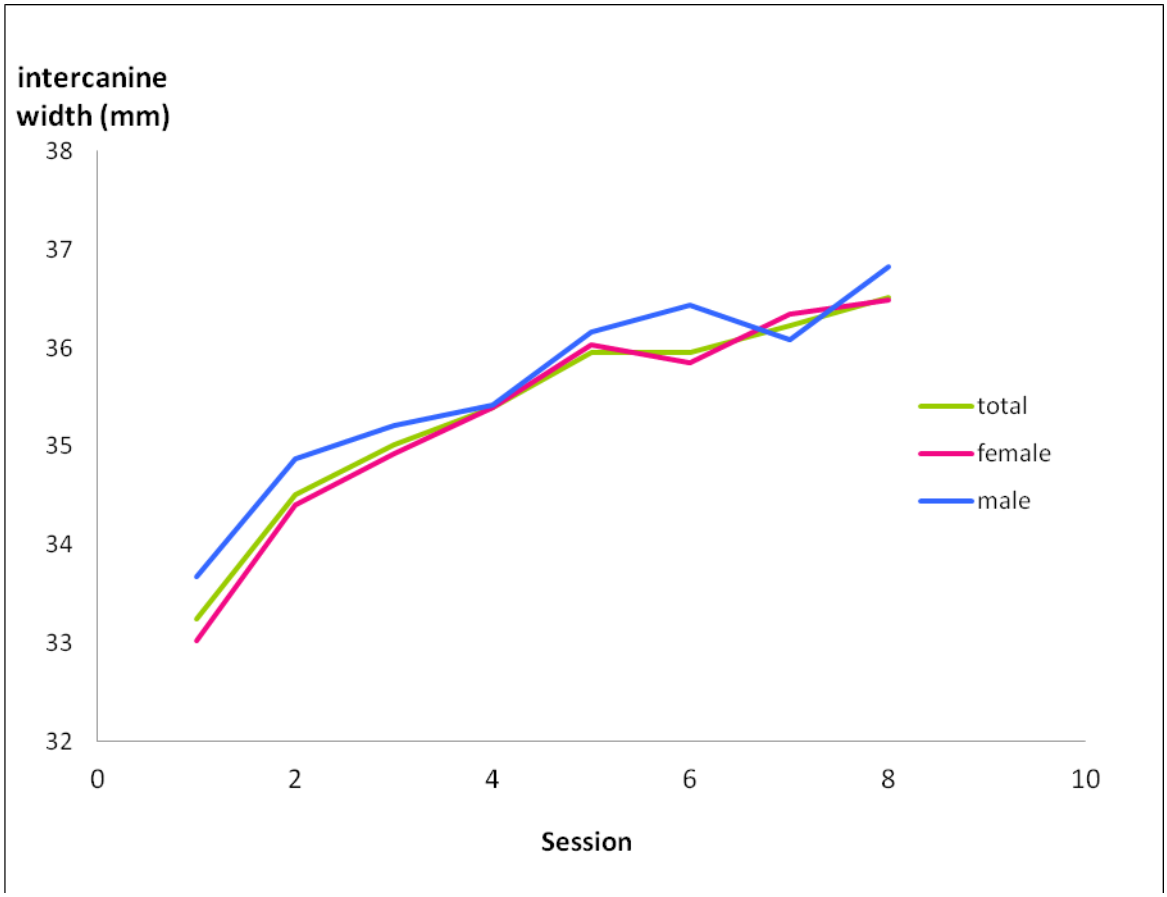

Fig. 8: Relation of increase of intercanine width per session in comparison of sex and collective.

As there is no significant difference between sexes, in Figure 8 it can be seen that the increase of intercanine width progresses nearly the same until session 3.
During the further sessions, there is more fluctuation of the measurements in the male than in the female sample.

3.5 Upper Lip Length

The upper lip change was highly significant ($p<0.001$). It increased from 17.0mm to 22.4mm in average. This is a total of 5.4mm within 8 sessions.

A steep increase can be seen (Fig.9) after the first session and within roughly one month, the lip length increased 2.9mm. Until the third session a relapse of 1mm took place and after that the upper lip length steadily increased at a slower rate than at the beginning. From the seventh session on the curve flattens and the values remain roughly the same.

There were no significant differences in sex ($p=0.454$)

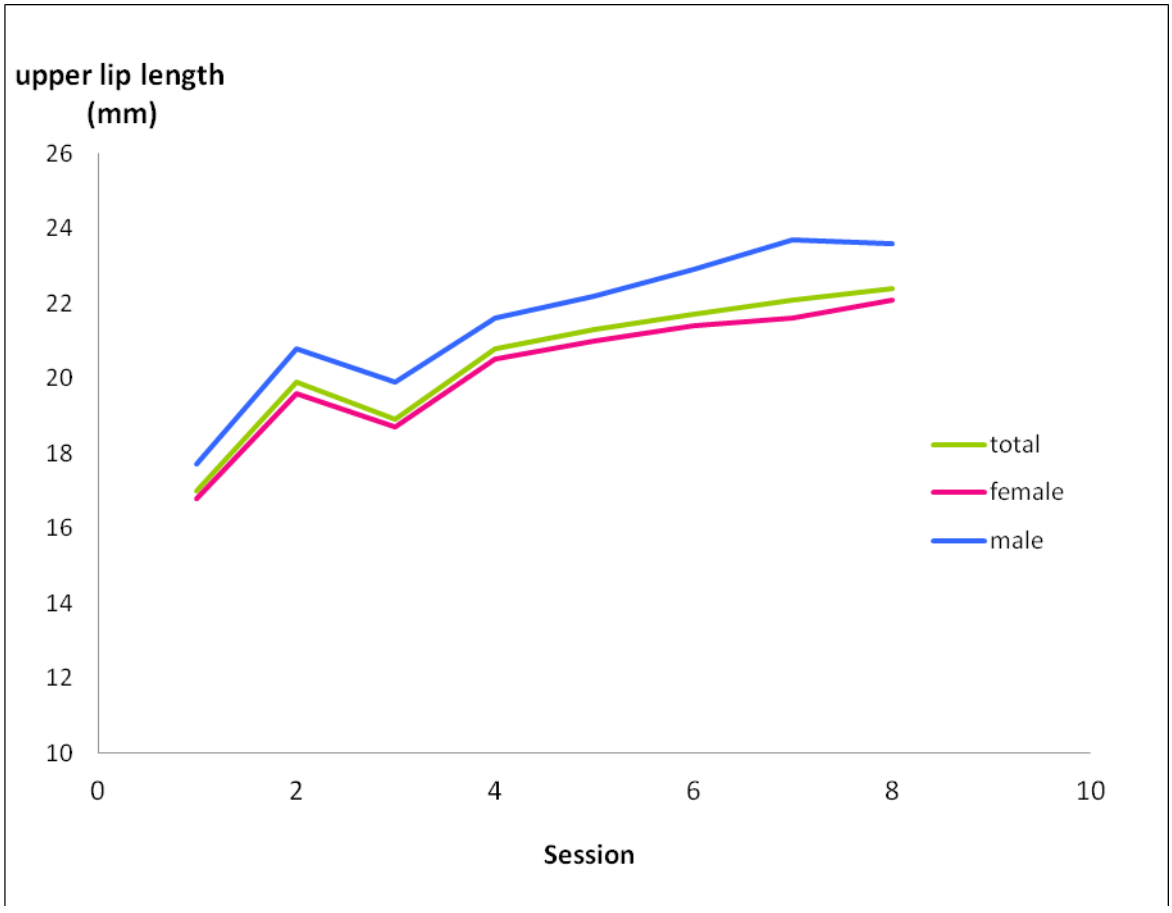

Fig. 9: Increase of upper lip length per session in comparison of sex and collective

3.6 Overjet

The overjet change was highly significant ($p<0.001$) and it decreased from 2.7mm to 1.5mm in average throughout 8 sessions. This is a total amount of 1.2mm.
A steep decline of 0.6mm can be seen between the first and second session and a flattened one in the following six session.
Also there was a significant difference between female and male ($p<0.001$). Women's overjet did decrease faster from a higher average value of 2.9mm and stayed higher throughout all the treatment time ($p=0.003$). Only at the end of the therapy the overjet showed the same average value of 1.5mm.

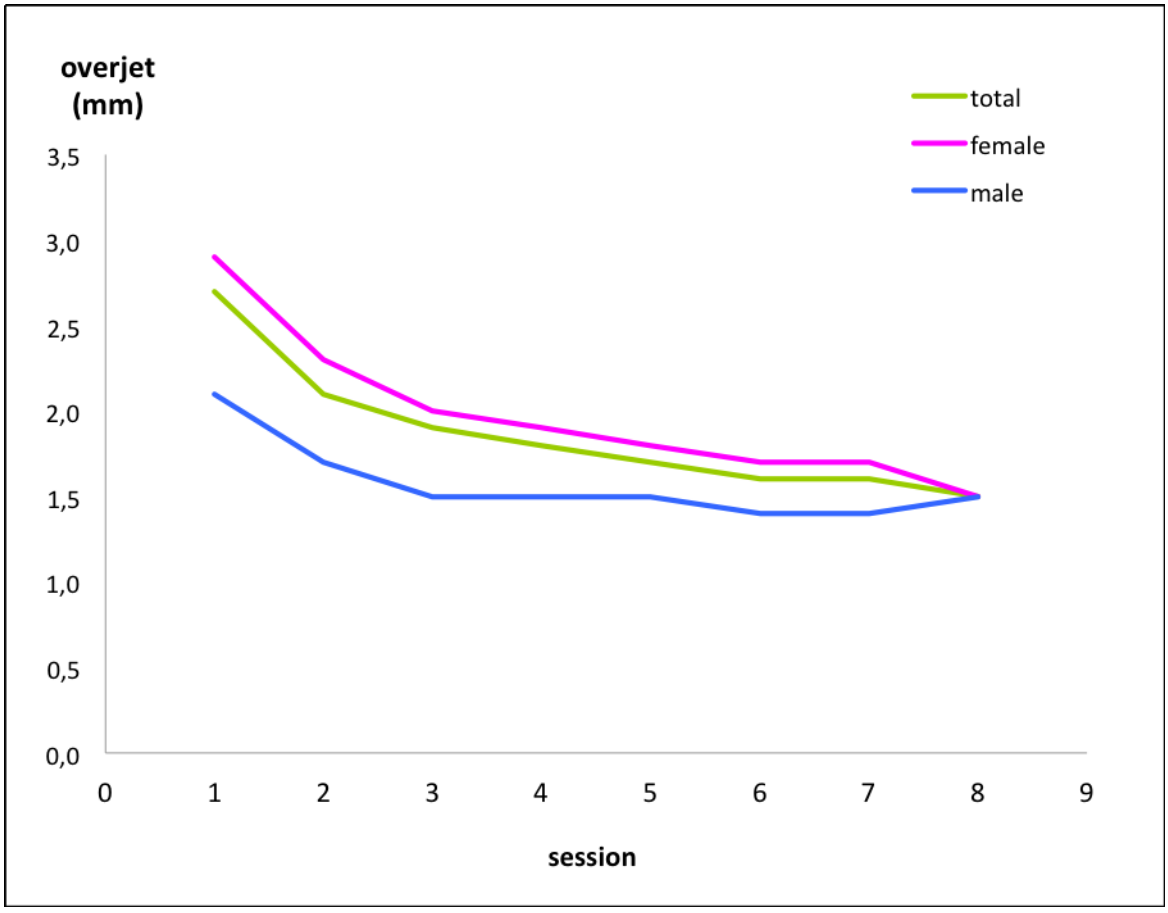

Fig. 10: Decrease of overjet per session in comparison of sex and collective

4 Discussion

It has to be mentioned that many of the patients are referred by the general dentist and therefore are preselected and already having some problems within the stomatognathic system.

According to the data, practicing muscle exercises induced changes of the soft tissue through subsequent adaption processes.
Muscle tissue has a great capability to adjust its anatomical, histochemical, physiological and biochemical properties to meet altered functional requirements (48). Adaption processes on the anatomical level take place by muscular changes such as in size, cross-sectional diameter or fibre properties (49). Typically, resistance training of a skeletal muscle, for example by means of repeated isometric contraction and relaxation, causes an increase in the thickness of the muscle and enhances muscular strength (50). Notwithstanding that some change might have occurred in the fibres and skin, it can be assumed, that most of the "change" has happened in the facial muscles, especially the orbicularis oris muscle and the tongue.
Significant changes in these patterns of the musculature can already be noticed after 3 months of performing exercises. Ingervall (1987) (51) reported, that he found significant increase in the bite force and muscle activity after 3 months of chewing exercises (51).

An increase in volume of the upper lip can be assumed, due to the consistent exercises executed by the patients, which is like "lip jogging". If the volume increases generally, the cross sectional center of the orbicularis oris muscle in the sagittal plane moves slightly away from the incisors.
At the same time the philtrum elongates during therapy, which was indicated by an increase in the upper lip measurement, which was taken in this study. This might has happened due to the mechanical stretching exercises, which increase the collagen synthesis (52). As a consequence of the elongation of the philtrum, the center of the muscle is lowered in the direction of the occlusal plane (Fig. 11). Though the upper lip measurement increased in average about 4mm, it can be

assumed, that the actual lowering of the muscle was less, due to the contour of the lip. If cut in the sagittal plane, the philtrum shows a curve and some of the length contributes to the extent in width and not in length.

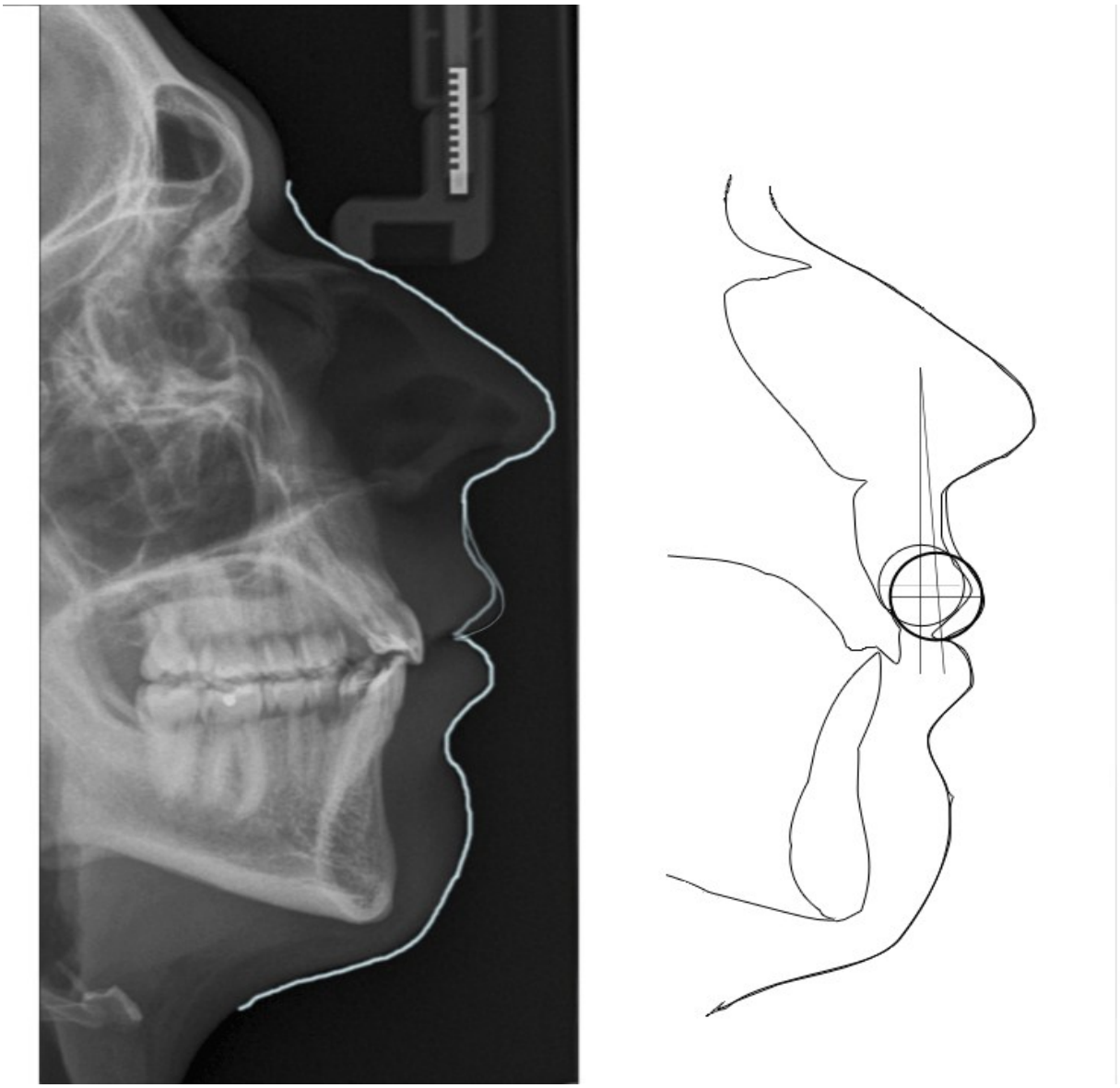

Fig. 11: *Left:* lateral cephalometric with a photoshopped superimposition representing the possible change of the lip contour. *Right:* schematic drawing of the contours of the cephalometric from the left side and showing the original and moved position of the center of the lip before and after treatment. Upper, thin circle = before therapy. Lower, bold circle = after therapy

Still these two changes of the resting position of the upper lip might lead to a slightly increased and more incisaly applied force on the incisor crowns, tipping them palatinally. The amount of force not only depends on the lip position, but also highly on the inclination and position of the incisors themselves. This was verified

in studies, measuring the direct force on the incisors, depending on their inclination and degree of overjet (53,54).
So it is possible, that a decrease of an excessive overjet, as found by measurements in this study, could be a direct result of these changes. As the incisors tip palatinally, they take up more space on the arch in the transvers plane and the position of the canine needs to change as well.

At the same time the tongue is trained to stay on the “spot”, slightly behind the palatinal side of the incisors, in the area of the rugae. As the balance between tongue and cheeks defines the tooth position (55), a repositioning of the tongue leads to changes of the force distribution and changes of tooth position should occur. Also, it is reported, that a lowered tongue position, in patients with myopathies and severe muscle problems, showed a significant increase in the height of the palatal vault and a narrower maxillary arch (56).
In another cross-sectional study of 1065 children between age 5 – 12, Galvez (33) stated that a high palatal vault was present in 85.8% of children with lip incompetency, in 73.6% of Class II cases and 65.3% in Class III cases. As this study was a remittance work, a distinction between the angle classes was not carried out. However, the angle classes apparently had no effect on the treatment results itself. It is also remarkable that although growth potential is determined by genetics to some degree, still function itself might has some effect on it, even in non-growing patients of the age above 18 (33).
Furthermore, it is shown, that a correlation between a lower rest position of the tongue, as in Class III patients and a small upper intercanine width, exists (38). An inverted rest position of the tongue, resting on the palate, should therefore contribute to a wider maxillary intercanine width (57).
In this study a high percentage of patients (75.89%) showed signs of a high vault. Correlated to the high vault it can be assumed that the maxillary arch was narrow, as presented in previous studies (33). This leads to the conclusion that in most cases a narrow arch is accompanied by a short intercanine width.

In this study the average intercanine width at the beginning of therapy was 33.3mm. Similar values are reported for non-treated patients by Paulino (46),

Forster (58) and Tibana (59), who also showed that this measurement commonly is stable in adults over a period of 7 years.

Particularly noteworthy are the actually quite tremendous changes of ICW of 3.2mm in average after 8 sessions exerting this muscular therapy. Most of the increase took place in the first 5 sessions, with about 0.5mm per session. No study, investigating intercanine width after myofunctional therapy, could be found for comparison.

As x-rays are not available for orofacial myologists, the indicator for incisors movement is solely based on the measurements of overjet. Unfortunately this does not give any information which teeth, either in the upper arch, lower arch or both, have contributed to the measurement changes.

Nevertheless it is a fact that the upper jaw guides the tooth position of the lower jaw if there is no crossbite present. Combining this with the increase of the upper intercanine width and removing the tongue from a lowered position and stopping a forward pushing of the lower incisors, it can be assumed, that the overjet reduction took place in the upper jaw as well. This could have been achieved by a retroclination of the upper incisors.

Considering the changes of the upper lip, a possible explanation for these changes might be attained (Fig. 12). As the upper lip might has slightly increased the force on the incisors, the position where it is applied changed and additionally, the counteracting force on the palatinal side of the incisors is reduced at the same time, by repositioning the rest posture of the tongue and so the incisors might aim for a new equilibrium (54). This state could be reached with a slight palatinal inclination. Whenever the incisors are retroclined palatinal, they

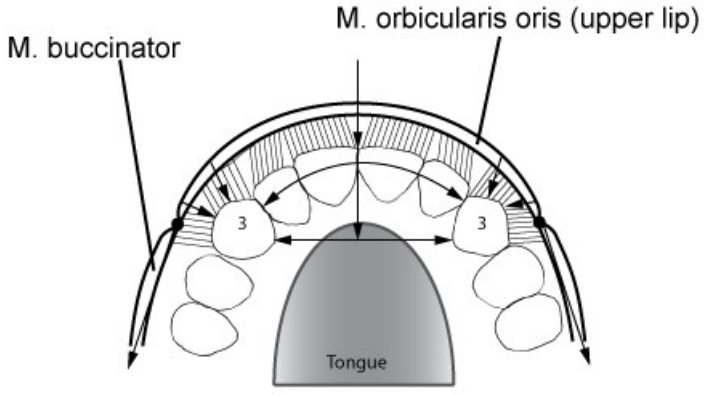

Fig. 12: schematically drawing of the surface relation of the upper incisors and canines exposed to the lip-force after therapy. Contracting forces pushing onto the disto-buccal side of the canine might be relatively small compared to the transmitted, lateral force from the orbicularis oris muscle.

need more space (60). If there are no spaces between the front teeth the movement is accompanied by distributing the force from the lips laterally towards the canines.

At the same time, due to the smaller surface and the more distal position the canines might not be exposed to the pressure of the lip as much as the incisors. As the pressure from the front teeth adds up, it might be enough to move the canines laterally.

Additionally it can be assumed, that the lowest resistance for the canine is on the disto-buccal side and it therefore starts to move to the lateral side. If this movement was tipping or bodily cannot be determined by the data available in this study. At the point when the forces of the tongue, lips and cheeks did establish a new equilibrium, e.g. after 5 sessions, tooth movement slowed down, and finally might has ceased.

5 Conclusion

A high correlation coefficient between myofunctional therapy in adult patients and intercanine width was found for the upper arch. Repositioning the tongue and practicing muscular exercises for the lips, tongue, face and posture lead to an increase of maxillary intercanine width of 3.2mm in average and changes of the upper lip length of 5.4mm within roughly eight months.

Changes in the dental formation can therefore be influenced by muscle therapy in non-growing patients.

6 Appendix

MATERIAL SAFETY DATA SHEET

ConvaTec, A Bristol-Myers Squibb Co. **DATE: March 17, 1998**
P.O Box 5254
Princeton, NJ 08543-5254

EMERGENCY CONTACTS:

Professional Services Dept.	Bristol-Myers Squibb	CHEMTREC
800-422-8811 or 908-904-2432	609-452-4000	800-424-9300
8:30am-5:00pm EST	After-hours 5:00pm-8:30am,	
Monday-Friday	Holidays, weekends	

The information below is believed to be accurate and represents the best information currently available. However, we make no warranty express or implied, with respect to such information, and we assume no liability resulting from its use.

PRODUCT IDENTIFICATION

PRODUCT NAME: Stomahesive® Skin Barrier

NATIONAL DRUG CODE/S: NDC 0003-0217-12
-15

COMPONENTS

Polyethylene
Silicone release paper
Sodium carboxymethyl cellulose
Pectin
Gelatin
Polyisobutylene

PHYSICAL DATA

A soft pliable light tan adhesive wafer with a plastic film backing on one side and a protective removable silicone release paper on the other side.

MSDS.07

7 List of figures and tables

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