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Mouth guard – for young and old

Today it is taken for granted that a helmet should be worn when cycling, elbow and knee protectors for roller blading and shin pads for playing football. Whilst even just a few years ago, helmets were something rather exotic on the world's ski slopes, nowadays they are seen as an important part of ski equipment. So we protect our head, knees, elbows and shins, yet still leave our mouth, teeth, gums, tongue and soft tissue unprotected during most sporting activities [9,10,26]. Studies confirm that around a third of orofacial injuries occur during sport [12,20,28]. These could be prevented with good oral protection [30].

Injuries to the lips, cheeks and tongue, as well as crown and root fractures, or even avulsion of one or more teeth and mandibular fractures can be avoided by wearing a mouth guard [21]. Whilst injuries to the soft tissue in the orofacial region are able to heal fully after trauma, teeth which have been fractured or knocked permanently out of their sockets cannot heal and must be replaced at great expense. This results in life-long costs [17]. Crown fractures represent a large proportion of such injuries [12]. They too lead to recurring costs for root canal treatment, composite build-ups and/or fabrication of an artificial crown, which has to be replaced from time to time [19].

A mouth guard can minimise and even prevent dental injuries [1,21]. A study conducted by Bemelmans et al. [1] states that the risk of injury without a guard is three times greater than when a guard is worn. A statistic based on 1 million sporting injuries in Australia confirms that approx. 30% fewer injuries to the teeth and lips result when a mouth guard is worn. Moreover, sport-related injuries to the tongue and mandible as well as concussion occurred considerably less frequently when a mouth guard was used [7].

The main functions of a mouth guard are to absorb and distribute impact energy in order to prevent fractures, lacerations and bite injuries. Thus, to fulfil these functions, the material used must be sufficiently elastic to absorb the force and, at the same time, rigid enough to distribute the pressure. A mouth guard must meet the following requirements [14,29]: biocompatibility, a high degree of protection, good fit, no impairment of breathing, speech or sporting performance, good durability, ease of cleaning and use, adjustment to a growing jaw and the ability to be worn together with fixed orthodontic appliances and prostheses. Currently there are five different types of mouth guard on the market [16]:

1. Ready-made mouth guard | These are preformed plastic guards which cannot be customized in the mouth. As they are not tailored to the teeth, the fit is poor and they are only kept in place by clenching your teeth. This can impair breathing and speech [29].

2. "Boil & bite" mouth guard | With this type, a preformed thermoplastic material is softened in hot water and placed in the mouth. It is then adapted to fit the maxillary

arch using the fingers and tongue, and by biting together (Fig. 1) [24]. How well the mouth guard is adapted depends to a great degree on the athlete's dexterity. Compared to a ready-made mouth guard, the fit is better, but the material is often too thin to offer sufficient protection [2,27]. It can be bitten through whilst being moulded, which means that these areas are very thin and thus unable to provide adequate protection [26]. However, there are also models with plastic inserts which do not become malleable in boiling water and therefore cannot be bitten through (e.g., Shockdoctor®). Furthermore, in the case of patients with orthodontic brackets or prostheses with pronounced undercuts, it may not be possible to remove the guard from the mouth after it has been adapted.

3. Two-component mouth guard | Here two different material types are mixed, put into a prefabricated tray and then adapted to the teeth by the athlete. The advantage of this mouth guard is that it cannot be bitten through during fabrication. A disadvantage is the lack of an impression of the mandible. In addition, as with "boil & bite" models, there is no subsequent finishing, which means that edges and corners could irritate the wearer. Moreover, this type of mouth guard is contraindicated in the case of athletes with pronounced undercuts (brackets, prostheses).



Fig. 1: A "boil & bite" mouth guard for patients with a multi-bracket appliance (POWRGARD 4•BRACES™, POWRGARD®).

4. Custom-made mouth guards | Custom-made mouth guards are mostly fabricated using ethylene vinyl acetate (EVA). EVA is non-toxic, elastic, absorbs virtually no water and is also easy to work with [3]. Furthermore, it can be produced in any colour (Fig. 2). After an alginate impression is taken by the dentist or orthodontist, plaster models of the maxilla and mandible are produced. A construction bite is additionally required in order to create impressions for the opposing jaw in the fixator or articulator. In the case of patients with neutral or distal occlusion, a unimaxillary mouth guard is normally used in the maxilla, as it is the upper central incisors which are affected in up to 85% of dental injuries [12]. The mandible is fixed in the mouth guard by individual impressions and thus protected against impacts and fractures. Moreover, since the mouth guard acts as an elastic absorbing element between the dental arches, the risk of concussion is also reduced. Accordingly, the mandibular teeth are protected from injuries, and the risk of condylar and intracranial injuries is reduced [17]. With a reverse incisor relationship, the mouth guard must be fitted on the mandible. A pressure-forming or thermoforming machine is used to laminate usually at least two EVA foils on top of each other. The thickness of the foil is directly related to the degree of energy absorption: the thicker the foil, the greater the protection [31]. However, there is a limit to the possible thickness of the mouth guard, as otherwise wearing comfort, breathing and speech may be impaired. For enhanced protection, a nylon mesh or DURAN® intermediate layer can be additionally inserted between the foils. The thickness of the foils can be adapted to the sport in question and the associated risk of injury.

According to Duarte-Pereira et al., a custom-made mouth guard ensures a better fit than a “boil & bite” model and is also more comfortable to wear [8]. Moreover, the former has a lesser impact on speech and breathing [1]. Whilst custom-made mouth guards are more expensive, they are more durable than other types [9]. On the other hand, the ready-made and “boil & bite” guards cause problems when speaking, closing the lips, breathing and swallowing.



Fig. 2: EVA foils in different colours and designs.

Consequently people often neglect to wear them [4]. Furthermore, custom-made guards can be designed by the dentist/orthodontist so that they can be used for approx. 2 years despite growth, changing dentition and orthodontic appliances.

5. Boxing mouth guard | This custom mouth guard made of ethylene vinyl acetate simultaneously covers the teeth in the maxilla and mandible. However, it impairs speech and is not popular among players of team sports [16].

Mouth guard and multibracket appliance | Patients undergoing orthodontic treatment are at a greater risk of suffering perforation of soft tissue in addition to tooth injuries due to brackets, bands and bows [15]. In addition, changes in the position of the teeth during treatment means that the mouth guard soon no longer fits properly. By hollowing/blocking out the model, it is possible to provide space for erupting teeth and changes in tooth position. These requirements can be best satisfied with a custom-made mouth guard. As already outlined, mouth guards fabricated using the “boil & bite” method and 2-component mouth guards can present problems to patients with fixed orthodontic appliances. During adjustment in the mouth, the material and brace can become bonded together, so the mouth guard can no longer be removed and the appliance is damaged.

Fabrication of a mouth guard for a patient with a multibracket appliance | Before alginate impressions of the maxilla and mandible can be taken by the dentist or orthodontist, the vestibular tooth surfaces with the brackets should be covered with an approx. 10 mm wide and approx. 1 mm thick wax strip (Fig. 3). This facilitates subsequent insertion and removal of the finished mouth guard. Since the surrounding alveolar process is also remodelled with tooth movement, the wax strip in the maxilla should extend to the movable mucosa. However, the wax strip should be shorter than the subsequent mouth guard.



Fig. 3: Vestibular tooth surfaces with brackets blocked out using an approx. 10 mm wide wax strip in the maxilla and mandible.

When the impression is then taken, the alginate consistency needs to be relatively firm in order to allow the entire depth of the fold and bands to be shown in the impression (Fig. 4). If the practitioner moves the cheeks and lips with the impression tray inserted, the bands will tend to be shown too large. This is beneficial as it reduces the effort required to insert the mouth guard. A construction



Fig. 4: An alginate impression of the maxilla with complete visualisation of the fold and bands.

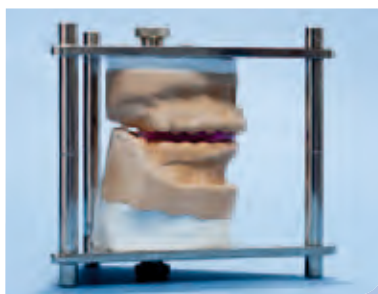


Fig. 5a: Maxilla and mandible model made of high-strength dental stone with an inserted construction bite in a Groth fixator.



Fig. 5b: Close-up of the construction bite with a 3 mm bite block in the posterior tooth region.



Fig. 5c: Maxilla plaster model with approx. 2.5 mm deep holes. These were made interdentally, approx. 1 mm gingival of the greatest dimension (corresponds to the arch of the multibracket appliance) in the anterior region, using a rose-head bur.



Fig. 5d: Maxilla model with holes in the anterior region to create retentions.



Fig. 6: Maxilla plaster model. To allow space in the mouth guard for the teeth which are to be moved as part of orthodontic treatment, these areas have been blocked out using light-curing resin (Triad®, DENTSPLY DeTrey).

bite is also necessary. A bite block in the posterior tooth region of at least 50% of the total thicknesses of the EVA foils used has proven expedient. If, for example, two EVA foils with a thickness of 2 mm and 4 mm are laminated, the bite block in the posterior region should be at least 3 mm. The construction bite must be taken sagittally and transversely in the desired mandible position. Using the construction bite, the maxilla and mandible models are articulated in a fixator or articulator (Fig. 5a and b). The use of a Groth fixator has proven reliable for this. To increase retention, protuberances are formed in the subsequent mouth guard. For this, a rose-head bur is used to drill holes interdentally into the model to a depth of approx. 2.5 mm, around 1 mm gingival of the greatest vestibular dimension (corresponds to the arch of the multibracket appliance) in the median-sagittal plane (Fig. 5c and d). In the finished mouth guard, these are hemispherical retentions which ensure additional hold for the guard, gingival of the arch in the multibracket appliance, and thus prevent it from slipping out easily. Before the first EVA foil is applied to the maxilla model, individual areas are blocked out with light-curing resin (e.g., Triad® Gel, DENTSPLY DeTrey) to enable the planned tooth movements (Fig. 6). In the mandible, too, if necessary, those teeth which are to be moved as part of orthodontic treatment must be blocked out, especially the occlusal surfaces and incisal edges (Fig. 7). The model is then covered with a 1 mm thick layer of thermoforming material made of polyethylene (e.g., COPYPLAST®, Scheu Dental) as a space maintainer (Fig. 8). This foil must be made of a material which does not combine with EVA. The space maintainer gives all the teeth a degree of space in order to allow the mouth guard to be worn for more than a year despite tooth movement. The space maintainer should be shortened so that it ends circularly approx. 4 mm before the vestibular and palatal limitation of the mouth guard (Fig. 9).

A 2 mm to 4 mm thick EVA foil (e.g., BIOPLAST®, Scheu Dental) is then applied over the COPYPLAST® foil (Fig. 10) and shortened with scissors to the base of the model. The

thickness of the material depends on the sport, age (strength) and size of the athlete. In sports where hard objects could hit the teeth, e.g., (ice) hockey and baseball, the

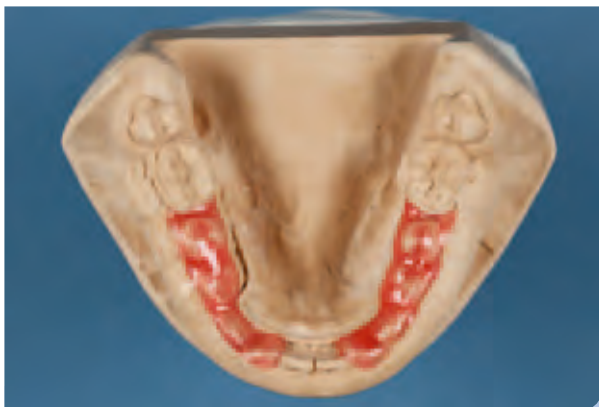


Fig. 7: Mandible model with Triad® block outs.



Fig. 8: The space maintainer foil applied to the maxilla plaster model (1.0 mm COPYPLAST®) is shortened using scissors.



Fig. 9: The maxilla model with shortened COPYPLAST® foil.



Fig. 10: Maxilla model with a shortened space maintainer foil and an EVA foil which has been applied on top and shortened (2 mm BIOPLAST®).



Fig. 11a: Maxilla model with the space maintainer foil and the first EVA foil directly after application of the DURAN® foil. To create the DURAN® insert for the anterior region, virtually vertical investment in the thermoforming device is recommended.



Fig. 11b: Model after rough shortening of a 0.75 mm thick DURAN® foil with marking of the vestibular extent of the intermediate insert.



Fig. 11c: Occlusal view of the model after marking the extent of the DURAN® foil.

integration of a hard insert can result in improved force distribution. For this a 0.75 mm thick foil made from polyethylene terephthalate glycol copolyester is adapted in the anterior region (e.g., DURAN®, Scheu Dental). To allow the DURAN® foil to be easily removed from the BIOPLAST® sub-layer for finishing, the EVA foil is sprayed with a silicone separating agent. The mandible model, to which the COPYPLAST® foil and the first EVA foil have already been applied, is then covered with the DURAN® foil in the anterior region only. After marking the circumference on the DURAN® foil, this foil is removed from the model and shortened using scissors and a bur. This hard elastic insert should cover the vestibular surface of the anterior teeth up to half way across the canines and slightly wrap

around the incisal edges (Fig. 11a-c). After shortening, the intermediate insert is positioned on the model. To ensure bubble-free application of the next EVA foil, perforations need to be made in the first EVA foil through to the model with a fine rose-head bur in those areas where the next foil could trap air, e.g., in the fold, at the deepest palatal point and also interdentally (Fig. 12).

Before the final 4 mm thick foil is laminated, the first BIOPLAST® foil and the final foil must be degreased with ethanol to ensure a good bond. If the second EVA foil is side-sensitive (e.g., BIOPLAST® XTREME PRO, Scheu Dental), it is vital that it is placed in the device with the adhesion side facing the first EVA foil in order to guarantee a reliable bond. Another way to make the mouth guard even more

personal is to add initials, a coat of arms or the club logo etc. between the two EVA foils (Fig. 13). The last EVA foil can include reinforcement (e.g., BIOPLAST® XTREME PRO, Scheu Dental). BIOPLAST® XTREME PRO foils have a wedge-shaped insert with a Shore hardness of 92 A, whereas the rest of the foil has a Shore hardness of 85 A and is thus softer. The wedge shape enables the reinforcement to be adapted to the individual extent of the anterior maxillary teeth. To conclude, after lamination of the second EVA foil (Fig. 14), the occlusal surface is heated and softened for approx. 120 seconds using the radiant heater of the thermoforming device (Fig. 15). The impressions are then created by immediately closing the fixator (Fig. 16 and 17). Covering the mandible model or soaking it in



Fig. 12: Model with a 2 mm thick BIOPLAST® foil plus DURAN® reinforcement in the anterior region. In the fold, holes were drilled through the EVA foil and into the plaster to allow air to escape.



Fig. 13: To personalise the design of a mouth guard, the wearer's initials, for example, can be printed on a transparent presentation foil and inserted between both EVA foils.



Fig. 14: Model after rough shortening of the final EVA foil.



Fig. 15: The occlusal surface of the final EVA foil is softened under the radiant heater of the thermoforming device.

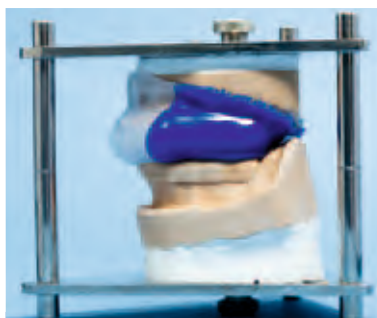


Fig. 16: Mandible and maxilla model in the Groth fixator after heating up the final EVA foil to create the impressions. The mandible model should be moistened before closing the fixator to prevent sticking.

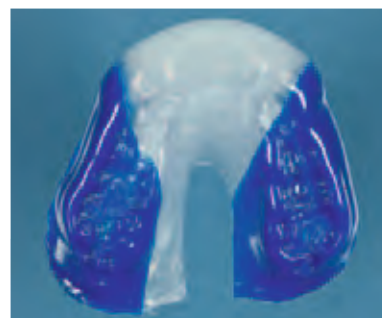


Fig. 17: Occlusal view of a roughly shortened EVA mouth guard with impressions prior to further processing.

water beforehand allows the model to be separated more easily from the EVA foil after the impressions.

Once the mouth guard has completely cooled down, the space maintainer foil can be removed (Fig. 18). The margins can then be cut using scissors and smoothed with polishing discs for flexible materials (e.g., Lisko, Erkodent or DIMO®PRO SLIM, Scheu Dental). An even smoother finish on the margins can be achieved with an alcohol flame. The mouth guard should be significantly shortened and thinned at the palate, as it could otherwise irritate the athlete. The finished mouth guard must be checked on the patient and, if necessary, adapted in terms of its fit and pressure points (Fig. 19–21).

Cleaning and storage of mouth guards | Directly after use, the guard should always be rinsed with cold or luke-warm water in order to remove saliva, bacteria and any deposits [6]. It should also be cleaned regularly with a toothbrush and toothpaste. Subsequent rinsing with a mouthwash solution can ensure a fresh flavour [6]. It is then expedient to allow the guard to air dry [30] before storing it in a box reserved for this purpose to prevent it from deforming. Prolonged exposure to sunlight is to be avoided, as this renders the material brittle. It is advisable to have the mouth guard checked regularly by the dentist or orthodontist in order to ensure a good fit and, in turn, safe use and optimal protection.

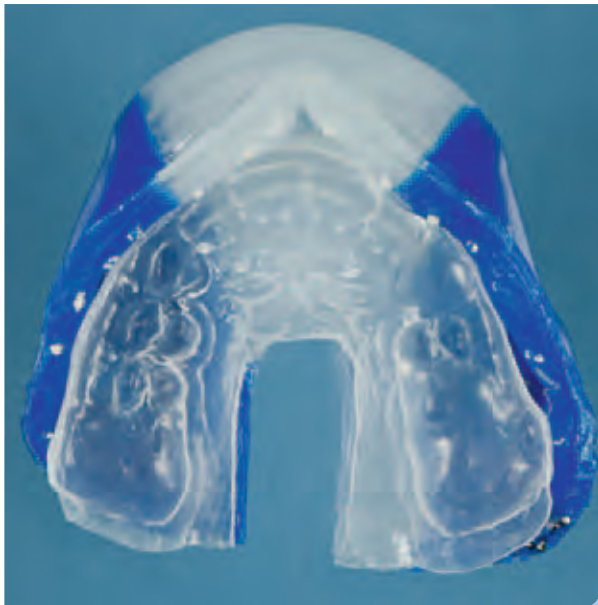


Fig. 18: The space maintainer foil (e.g., COPYPLAST®) is removed before the margins are shortened and then smoothed.

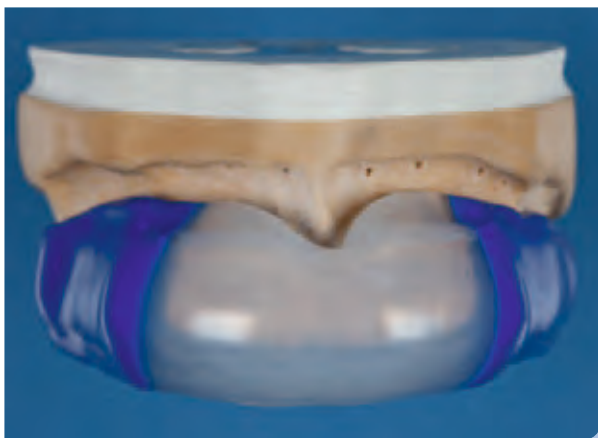


Fig. 19: A finished custom-made mouth guard on the model.

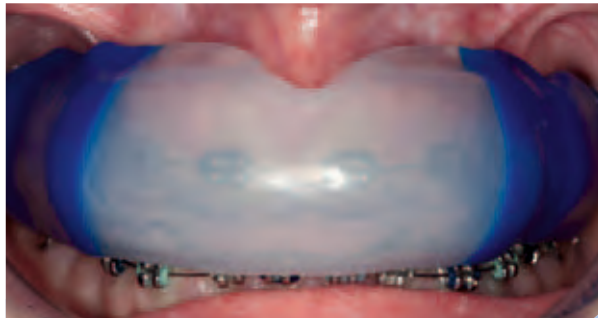


Fig. 20: Intraoral view of a patient with a multibracket appliance and custom-made mouth guard.

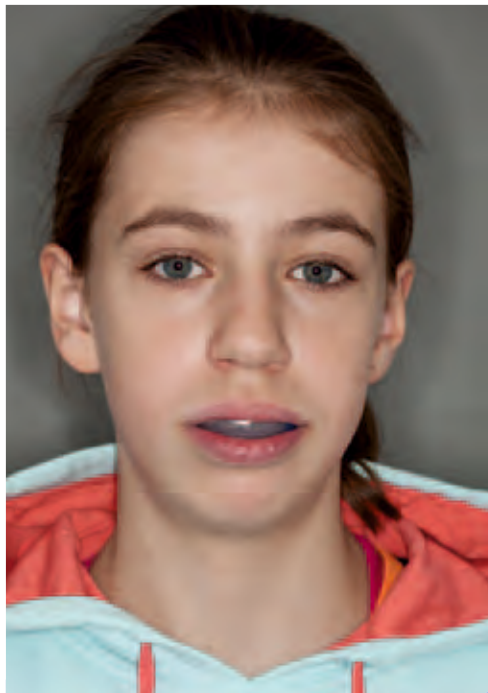


Fig. 21: Extraoral view of a patient with a multibracket appliance and custom-made mouth guard.

Mouth guards and enhanced performance |

There is evidence to suggest that changes in occlusion influence the mobility of the cervical, thoracic and lumbar spine.

Occlusal splints can improve the stability of these sections of the spine [18]. The change in posture would seem to have a positive effect on athletes' performance. Based on a study by Ohlendorf et al., it has emerged that wearing an individually adapted mandibular splint combined with mandibular displacement led to a quantitative improvement in the execution of individual movements [25].

Conclusion |

Contact, high-speed and racket sports present a major risk in terms of tooth injuries. The German Association for Dental, Oral and Maxillofacial Surgery recommends the use of a mouth guard for the following sports [23]: American football, apparatus gymnastics, baseball, basketball, boxing and other martial arts, cycling, football, handball, hockey, horse riding, ice hockey, roller blading, rugby, skateboarding and water polo.

Wearing a mouth guard does not necessarily prevent injuries [21]. It is, however, undisputed that the frequency and severity of injuries can be reduced [5,19,21]. One of the key factors for effective protection is a good fit. Many of the criticisms made of mouth guards, e.g., poor comfort and problems with breathing and speaking, are associated with ready-made and "boil & bite" mouth guards. When asked about their experiences with various types of mouth guard, athletes stated that they had the fewest problems with custom-made mouth guards [1,22].

Impaired aesthetics was a further point which athletes criticised [9]. A personal mouth guard can be created using the various coloured EVA foils. More information and publicity about

custom-made mouth guards is needed in sports clubs and schools in order to turn this necessary protective item into a cool piece of sports equipment. Thanks to basketball, handball and hockey players who can be seen on TV wearing mouth guards, there is now greater awareness of the need for oral protection. As specialists in oral protection, dentists and orthodontists need to now take on this challenge.

Owning a mouth guard does not automatically translate into frequent use [13,28]. It is necessary that children regularly wear a mouth guard when they take up a sport so that the guard becomes an accepted part of sports equipment. Correct fit is all important for acceptance and regular use [4]. Particularly for patients undergoing orthodontic treatment, a custom-made mouth guard is important, as tooth movements and mandibular dislocation must be taken into account. Given the greater degree of tooth movement and the orthodontic appliance, these patients in particular are exposed to a higher risk of injury [24].

For sports such as boxing and American football, mouth guards are an essential piece of equipment. Dirk Nowitzki (basketball) and many handball players also wear a mouth guard. Yet, they remain uncommon among football players. Nevertheless, studies confirm that footballers (approx. 23%) also suffer orofacial injuries when not wearing oral protection [11,21]. That's why more information and education is required in these areas. Even today, trainers and parents need to be informed by dentists and orthodontists in order to increase the level of acceptance of mouth guards. Accordingly, as a first step towards prevention, dentists and orthodontists should ask patients about their sporting activities when taking their history. The initiative

launched by the Berlin State Sport Federation (Landessportbund) and the Berlin Dental Association, and also the stance of Stiftung Warentest (consumer organisation) should provide good examples for broader public relations work.

The authors:

Dr Min-Jung Oh,
Prof Dr Paul-Georg Jost-Brinkmann

Dr Min-Jung Oh

1998–2003 Dentistry degree at the Free University of Berlin
2003–2011 Employment in an independent dental practice
2009 Doctorate
2011–2013 Employment in an orthodontic practice
Since 2013 research assistant in the department of orthodontics and paediatric dentistry at Charité University Hospital, Berlin

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Correspondence address:

Prof Dr Paul-Georg Jost-Brinkmann
Dr Min-Jung Oh
Charité – Universitätsmedizin Berlin
CharitéCentrum für Zahn-, Mund- und Kieferheilkunde (centre for dental, oral and maxillofacial surgery)
Abteilung für Kieferorthopädie, Orthodontie und Kinderzahnmedizin (department of orthodontics and paediatric dentistry)
Assmannshäuser Strasse 4–6
14197 Berlin, Germany
Tel.: +49 (0) 30 450-562522
Fax: +49 (0) 30 450-562952
E-mail: paul-g.jost-brinkmann@charite.de