STUDY in Focus

02 2021

Registration Materials and their Deformation Forces during Bite Registration

Commissioned by

KETTENBACH DENTAL
Simply intelligent

A special publication by

Deutscher Ärzteverlag

Registration Materials and their Deformation Forces during Bite Registration

Classically, the model is transferred to an articulator in two steps:

1. **Set the first model with respect to the reference plane**

2. **Set the opposing jaw model using bite registration.**

The fact that often insufficient attention is paid to the first step and the errors to be expected in clinical procedures has already been the subject of several publications by the author [3, 4, 7].

In the second step, it is important to map the jaw position in all six degrees of freedom in bite registration with as little hindrance as possible, because the three coordinates in the transversal, sagittal and vertical planes simultaneously form three position axes (the longitudinal, transversal and vertical axes) around which the lower jaw can tilt [see Fig. 1].

The question now arises: to what extent the presence of the registration material influences this procedure. This question forms the basis for the following study, the aim of which was to measure the deformation forces of various registration materials as accurately as possible under realistic conditions in order to obtain specific insights into the use of these materials with different registration techniques. As the deformation force is also a function of material displacement, it should also be measured how high the difference in the force required is if the dentition is asymmetrical on the left and right and e.g., only reaches the second premolar on one side, but up to the second molar on the other.

Experimental design

The Zwick Z010 universal testing machine, combined with the testControl II control unit and testXpert III measurement software, was used to measure the deformation forces in the Kettenbach Dental research laboratory in Eschenburg.

In order to simulate the clinical situation as realistically as possible while ensuring repeatability, the machine pressed a real upper row of teeth into the respective registration material with an advance speed of 300 mm/min over a distance of 20 mm. The teeth were mounted in a Frasaco upper jaw model, which was attached to the machine.

Only the posterior teeth from the first premolar to the second molar were mounted, i.e., four teeth on the left and right respectively [see Fig. 2].

Removal of the two molars also allowed the effect of shortened row of teeth on the deformation force to be measured.

The row of teeth was moved against the lower pressure plate of the machine. In order to minimize temperature fluctuations (especially using waxes), a polyoxymethylene (POM) mold was attached, which thermally isolated the registration material from the stainless steel pressure plate while ensuring a standardized shape and thickness of the registration material to be tested. The machine automatically stopped the advance motion and measurement as soon as contact was made between the row of teeth and the base of the POM mold.

The time of this contact was determinable both geometrically from the advance and from the force diagram curve, which increased steeply at this

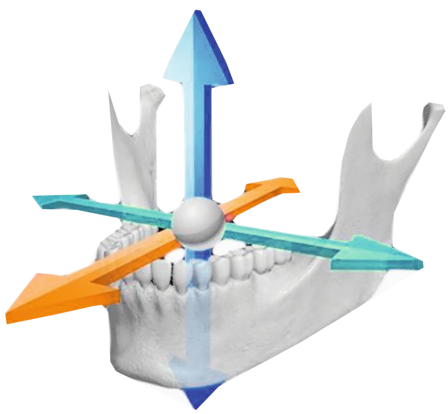


Fig. 1 In the second step, it is important to map the jaw position in all six degrees of freedom in bite registration with as little hindrance as possible.

point. Two points in particular were considered for evaluation:

1. **The initial contact of the teeth with the registration material at a distance of 4.5 mm from the base of the POM mold**

2. **A point 1 mm before contact of the teeth with the base of the POM mold.**

Fig. 2 Only the posterior teeth from the first premolar to the second molar were mounted, i.e., four teeth on the left and right respectively.

Each measurement was carried out five times and each series was evaluated by mean and standard deviation. Materials from mixing syringes were each applied into the recess of the POM mold and smoothed up to its upper edge [see Fig. 3].

The force measuring machine used could measure force as a function of distance, but was unable to differentiate force vectors or tilting forces. In order to represent these tilting forces around the longitudinal axis of the lower jaw, which may actually occur in jaws with asymmetrical dentition due to the unequal resistance of the registration material on both sides, all measurements were carried out twice, once with four teeth per side (2x4), and once with only two premolars per side (2x2) [see Figs. 4 + 5].

Half of the difference in deformation force between 2x4 teeth and 2x2 teeth measured on the complete model should approximately correspond to the tilting force acting on the lower jaw when penetrating the registration material [see Fig. 6].

The following materials or products were investigated in the study:

A silicones:
- Futar from Kettenbach Dental
- Futar D from Kettenbach Dental
- Futar Cut & Trim Fast from Kettenbach Dental
- Panasil Putty Fast from Kettenbach Dental

Waxes:
- Aluwax Denture from Aluwax
- Beauty Pink from Miltex

The deformation force in waxes is highly temperature-dependent. However, waxes can only be used for bite registration in the temperature range in which they can be handled,

Fig. 3 Each measurement was carried out five times and each series was evaluated by mean and standard deviation. Materials from mixing syringes were each applied into the recess of the POM mold and smoothed up to its upper edge.

Fig. 4 + 5 In order to represent tilting forces around the longitudinal axis of the lower jaw, which may occur in jaws with asymmetrical dentition due to the unequal resistance of the registration material which may occur on both sides, all measurements were performed twice, once with two premolars per side (r) and once with four teeth per side (l).

i.e., removed from the water bath and applied to the teeth. In principle, this would also be possible with wax at room temperature, but the force required for deformation then increased sharply and could no longer be determined due to the 1 kN limitation of the measuring sensor. In contrast to actual bite registration, this investigation also required a little more time between the heating in the water bath and the actual force measurement. At the same time, the wax should not be significantly pressed during handling in order to keep the sheet thickness as uniform as possible.

The best compromise was achieved at a 45°C water bath temperature. First, the required number of layers was cut to size for the recess in the POM mold, heated to 45°C in the water bath, and then placed in the POM mold, which, although not actively heated, protected the wax from cooling too quickly. The wax temperature was then 42°C at the time of force measurement.

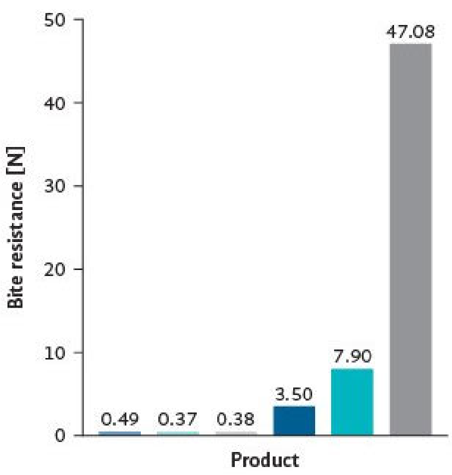
The following was also observed while preparing for these measurements:

1. The thickness of the wax sheets varied, which made it difficult to produce test specimens of uniform thickness. These varied between 5.3 and 6 mm.
2. When the wax was melted and poured into the POM mold, the bite resistance after cooling to the test temperature of 42°C was up to three times higher than for sheets heated in a water bath. This was the reason for not liquefying the wax during these measurements.

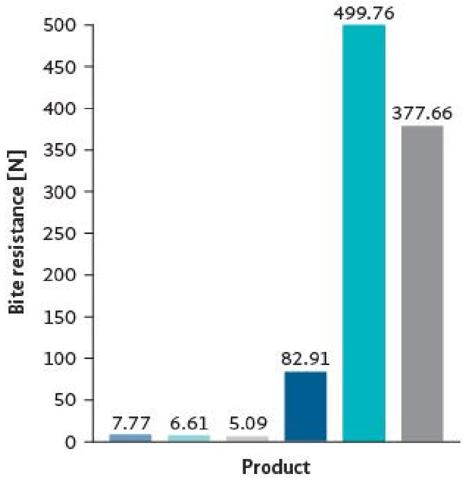
Fig. 6 Half of the difference in deformation force between 2x4 teeth and 2x2 teeth measured on the complete model should correspond approximately to the tilting force acting on the lower jaw when penetrating the registration material.

Measured values in direct comparison

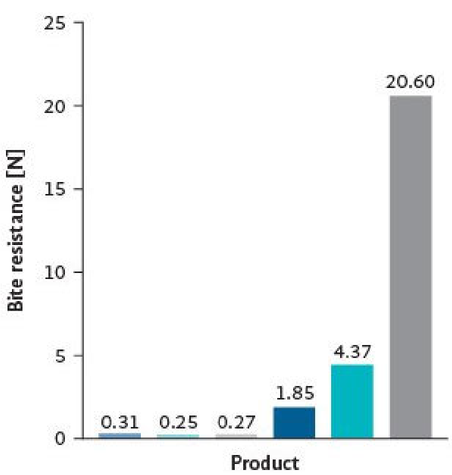
Bite resistance at a 4.5-mm tool distance
(start of bite) 2x4 posterior teeth



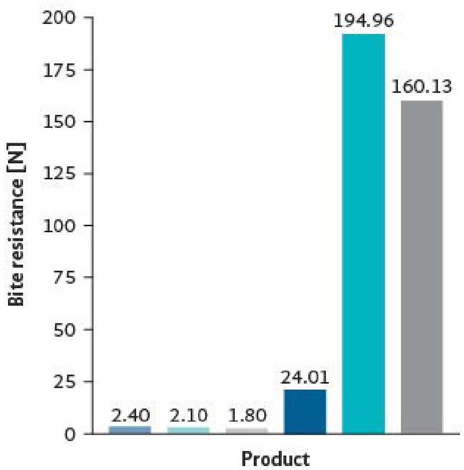
Bite resistance at a 1.0-mm tool distance
(just before biting through) 2x4 posterior teeth



Bite resistance at a 4.5-mm tool distance
(start of bite) only primary molars



Bite resistance at a 1.0-mm tool distance
(just before biting through) only primary molars



Futar | Futar D | Futar Cut & Trim | Panasil Putty Fast | Beauty Pink Wax | Aluwax

Outcome

In general, particularly high consistency of the measured data was observed with addition cross-linked silicones, which were applied with mixing tips. Here the deviations between the measurement runs with the same material were hardly measurable. In the case of kneading silicones, the deviations in the deformation force between the respective measurement runs were slightly higher and finally, in the case of waxes, comparatively significant.

Kneading silicones require more than 10 times the force to deform than the silicone cartridge materials tested (Futar). At 42 °C, Beauty Pink required about one hundred times the deformation force of Futar Cut & Trim Fast—the material that required the least force to form the teeth—which averaged 5.09 N.

For all the materials tested, the force required for deformation was significantly greater for dentition that extended up to the second molar than for dentition that only extended to the second premolar. This was to be expected, as the force required for deformation is a function of material displacement, which is much greater in the case with molar biting than for premolar biting (or even for prepared cores). For the waxes tested, this difference was 2.3 to 2.5 times the force required to form the full dentition in the registration material; for the kneading silicone this was about 3.5 times, while for the syringe silicones it varied from 2.8 times for Futar Cut & Trim Fast to almost 6 times for Futar.

However, the actual asymmetric force applied to the lower jaw during bite registration is more important than the relative difference. The smallest forces may differ by multiple times, but if in the end the difference is only of 1/10 N, the relevance with regard to bite registration has to be questioned. This is different for forces of 10 N or even more, however, if the jaw has asymmetrical dentition on the left and right! This would expose structures such as jaw joints to asymmetric loads during bite registration in such a way that would potentially create an unintended change in position of the lower jaw during bite registration. The difference in force, or the tilting force around the longitudinal axis of the jaw applied during registration on the lower jaw, is therefore calculated from the formula 1/2 F (2x4 teeth) – 1/2 F (2x2 teeth) and corresponds to half of the measured difference between the measurements carried out with eight teeth and with four teeth:

Material	Tilting force
Futar	5.9 N
Futar D	2.3 N
Futar Cut & Trim Fast	1.6 N
Panasil Putty Fast	29 N
Aluwax Denture	109 N
Beauty Pink	152 N

N - Newton

Now, the parameter Newton is less familiar than the force exerted on the earth by a certain mass in grams. Rounded off, 10 N corresponds to a mass of 1000 g, so here we consider equivalents between roughly 160 g (1.6 N) and 15.2 kg (152 N), which helps facilitate the idea of the magnitude of this tilting force together with conceivable effects in bite registration.

In principle, it can therefore be concluded that the lower the force required to deform the registration material, the lower the possible effect of asymmetrical dentition in terms of unintended influences on the jaw position registered during bite registration.

Consequences for practice with different registration techniques

There are properties that are equally important for registration materials across all registration techniques, including:

- They must be layered on the teeth and not flow,
- Tooth impressions in the registration material must not spring back, but remain absolutely fixed,
- They must ensure precisely defined model assignment for mounting in the articulator and must therefore not deform under pressure, e.g., from the model's own weight.

However, there are other properties that differentiate the suitability of registration materials depending on the registration technique applied, including application options, processing time and, of course, also the force required to form the dental impressions. As it is not possible to list each registration technique individually here, they are grouped into categories as follows:

I. Hand-guided bite registration

The prevailing view of jaw movement plays an important role in bite registration. In the joint-oriented view, the attempt is made to move the patient's lower jaw as closely as possible to how an articulator would be moved. However, in the articulator, the axis mechanically fixes the pivot point for vertical movements, which is only predictable in the patient's mouth if the translation is pushed to a stop in the upper gap of the jaw joints. Mongini showed, however, that the limit movements of the jaw joints, and therefore the stop to which they can be pushed, are subject to significant changes when jaw joints change shape with loads like those that occur due to occlusal changes. Mongini referred to such changes in the joint as „remodeling" [1–2].

The more forcefully the lower jaw is manipulated on the patient during bite registration, the less important the force required to deform the registration material is likely to be, so that waxes and modeling compounds can also be used without any problems. At the same time, they have the advantage that they only represent fissures and interdental spaces relatively indistinctively and therefore sometimes fit better on the plaster model.

However, bite registration techniques in which the patient's lower jaw is forcefully pushed back (as originally demanded by the gnathology experts) no longer enjoy the same popularity as they did a few decades ago. In the meantime, some rather try to push their patient's lower jaw more sensitively into a position that seems right to them, whichever criteria serve as a yardstick. To enable the practitioner to better feel the play of various resistances on the patient's lower jaw, they give preference to registration materials that can be formed with as little force as possible.

II. Constructed bite registration

If the lower jaw is to be pushed into a constructed position, e.g., which has been determined using an intraoral supporting pin to measure the jaw position above a certain pressure of the supporting pin on a measuring plate, waxes and modeling silicones are less suitable as registration materials, because it is difficult to form tooth impressions into them without the patient opening their mouth during insertion. When closing, however, they would then possibly miss the target point. Instead, a material is needed that can be applied without the patient losing contact between the supporting pin and the measuring plate, which can be achieved with an A-silicone applied with a mixing tip.

III. Registration techniques for capturing therapeutic results

The oldest of these methods is myocentricity, introduced by Jankelson more than 50 years ago, and around which several misunderstandings have emerged since then. Recently, a textbook on myocentricity was published, however, compiling background and facts, and comparing the approaches originally described by Jankelson with modern ones [8]. Here, the therapy is carried out by applying low-frequency TENS, with which tensions in the masticatory muscles are relaxed. The aim of myocentric bite registration is to map the relation of the lower to the upper dental arch unhindered in the bite registration material, which occurs when the muscle tension is reduced accordingly. For years, A-silicones have become established worldwide as registration materials, especially those variants that can be deformed for a sufficiently long time with as little force as possible, but then set as quickly as possible to a high final hardness („snap set").

Today, there are more and more manual therapists that specialize in craniomandibular dysfunction (CMD) therapy. If they succeed in mobilizing temporomandibular joints or releasing their compression, the dentist often prefers to accept this improved situation without further action, e.g., for the purpose of splint therapy, instead of possibly causing renewed compression in the joints by manipulation. Here, registration techniques usually work best where there is as little external force exerted as possible, which means that it is best to use registration materials that can be formed with the resulting low forces.

Perhaps the simplest form of therapy involves chewing on a 'FreeBite air', the special shape of which can often reduce tension in the masticatory muscles by 50% or more after just 5–10 minutes [5]. The forces acting on the mandible reduced in this way cause a greater or lesser change in position, which is expressed in other tooth contacts when the patient takes the 'FreeBite air' out of the mouth with the body in an upright posture and gently feels for the initial occlusal contacts. If the same contacts are to be made during bite registration with the muscles relaxed, the process must be as close as possible to the empty closure of the mouth, which can be achieved with an A-silicone that forms itself to the teeth practically unnoticed, i.e., with particularly low force.

IV. Registration taking the traction vectors of the elevators into account

W. Schöttl described a technique he called „Muscular Grip" in 1978 [9]. During this process, the patient closes their mouth into the registration material against resistance from the dentist's hand, who presses the tip of the chin caudally at the same time. As this registration is carried out with some force, waxes can also be used to good effect as registration material in the process. However, with this grip, it is difficult to control the force vectors because, e.g., with a less pronounced chin, pressure directed with a dorsal vector is required to avoid slipping.

Conversely, without any external manipulation, it is possible to capture the force vectors of the elevators on the resilient compensating air cushion of a 'FreeBite air', which the patient simply compresses between the teeth until the required bite height, e.g., for a splint, is attained [6]. This jaw position is then keyed to the anterior teeth by injecting a fast- and hard-setting A-silicone between them using a mixing tip. The 'FreeBite air' is then removed from the mouth and replaced by a second application of a fast-setting A-silicone which is formable with as little force as possible, which picks up the occlusal contours of the posterior teeth while the patient feels the final position in the anterior key with their incisors.

Outlook

Conversely, variations in temperature and humidity have almost no influence on the dimensional stability of A-silicones—this is a separate topic for further metrological comparison.

Another approach for our own scientific measurements would be e.g., to investigate the resilience of registration materials as a function of pressure during articulation.

In this step, the models should be keyed as clearly as possible with each other. The aim of a scientific study could be to discuss the effects of different material hardness—e.g., A-silicones with different hardness and consistencies compared to wax—on the final articulation in order to provide the user with decision-making criteria for selecting the appropriate registration materials.

RAINER SCHÖTTL, D.D.S. (USA)
Institute for Temporo-Mandibular Regulation
Schuhstraße 35
91052 Erlangen
Phone 09131–205511
mail@itmr.eu

Bibliography

1. Mongini, F., Remodelling of the mandibular condyle in the adult and its relationship to the condition of the dental arches. Acta Anat (Basel), 1972. 82(3): p. 437–53.
2. Mongini, F., Influence of function on temporomandibular joint remodeling and degenerative disease. Dent Clin North Am, 1983. 27(3): p. 479–94.
3. Schöttl, R., Die Kauebene: Referenzen und deren Konsequenzen im Artikulator. Myobyte, 2013. 5(2013): p. 27–38.
4. Schöttl, R., Die Programmierung von Vertikalbewegungen im Artikulator. Quintessenz Zahntechnik, 2014. 40(7): p. 886–899.
5. Schöttl, R., CMD-Bissnahme in 6 einfachen Schritten.BiteBlog 2018; Internetadresse: https://biteblog.de/freebite/bissnahme/cmd-bissnahme-in-6-einfache.html.
6. Schöttl, R., CMD-Bissnahme in 6 einfachen Schritten.2018; Internetadresse: https://biteblog.de/freebite/bissnahme/cmd-bissnahme-in-6-einfache.html.
7. Schöttl, R., Die Einstellung von Artikulatoren für die okklusale Gestaltung. Quintessenz Zahntechnik, 2019. 45(7): p. 894–904.
8. Schöttl, R., Myozentrik – Fakt und Meinung. 2. erweiterte Ausgabe ed. 2020: MediPlus.
9. Schöttl, W., DasTMR-System Prä-Therapie als Voraussetzung der Rehabilitation. 1978, Berlin <etc.>: Quintessenz Verlag. 259 S.

Publishing details

Publisher: Deutscher Ärzteverlag GmbH
Dieselstraße 2, 50859 Köln
CEO: Jürgen Führer, Patric Tongbhoyai
Phone 02234 7011-0 (switchboard)

Authors: Rainer Schöttl

Printer: L.N. Schaffrath GmbH & Co. KG DruckMedien, Marktweg 42, 47608 Geldern, Germany
Photos: Kettenbach GmbH & Co. KG
This special publication is published on behalf of and within the responsibility for content of Kettenbach GmbH & Co. KG
Im Heerfeld 7, 35713 Eschenburg, Germany

This special publication is published outside the responsibility of Deutscher Ärzteverlag.