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In vitro splint rigidity evaluation – comparison of a dynamic and a static measuring method

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Abstract – *Objectives*: The aim of this *in vitro* study was to investigate a dynamic and static tooth mobility assessment method in terms of reproducibility and correlation. *Materials and Methods*: A custom-made artificial model was used. The central incisors simulated 'injured' teeth with increased mobility, and the lateral incisors served as 'uninjured' teeth with physiological mobility. To assess tooth mobility, three consecutively repeated measurements were taken, in the vertical and horizontal dimensions before and after splinting, using the Periotest method as well as the Zwick universal testing machine. Reproducibility of the measurements was tested using ANOVA and the Bonferroni *post hoc* test ($\alpha = 0.05$). Correlation was analysed using Spearman's rank correlation ($\alpha = 0.05$). *Results*: No significant differences were found when comparing the three consecutively taken Periotest values and the vertical Zwick values ($P > 0.05$). In the horizontal dimension, the first Zwick values differed from the second and third values ($P < 0.05$). Only a few random correlations ($P < 0.05$) were found when comparing the two assessment methods. Horizontal and vertical measurements within one method did not correlate ($P > 0.05$). *Conclusions*: The Periotest and vertical Zwick values are highly reproducible. The measurements of the two methods do not correlate; therefore, a conversion of Periotest values into metric displacement data is not feasible. The two methods provide different valuable information about tooth mobility. The Periotest method describes the damping characteristics of the periodontal ligament while the Zwick method reveals quantitative metric values.

Splinting is an integral component in the treatment of dento-alveolar injuries (1, 2). The splint rigidity should be adapted depending on the type of trauma. Trauma involving the periodontal ligament (PDL), such as dislocation injury, requires flexible splinting (1–5) to allow transmission of functional forces for improved healing outcome (6, 7). The splint properties for treating hard tissue injuries, such as horizontal root fracture and alveolar process fracture, range from semi-rigid to rigid (1, 5). Fulfilling most of the requirements are modern trauma splints (1, 3), which consist of reinforcement materials attached to the dental arch using an acid-etch technique and flowable resin composite (1, 2).

For splint classification, in terms of indication, objective rigidity evaluation is necessary. Former studies, focussing on splint rigidity, were *in vivo* investigations involving healthy (8, 9) or injured (10) patients or *in vitro* experiments with artificial (1, 2, 11–14) or animal models (15, 16).

Based on the principles of static (12, 17–21) or dynamic testing (1, 8, 22–24), a wide variety of objective tooth mobility assessment methods is available. *In vitro* splint rigidity studies have used static techniques such as universal testing machines (11–14) or a periodontometer (16), in which a load is applied and the resulting tooth movement is metrically measured. Other investigators have assessed tooth mobility with the dynamic Periotest® method (1, 2, 15, 16, 25), which evaluates the damping characteristics of the PDL (2, 8, 26). In addition to the *in vitro* applicability of the Periotest, this method is also widely used for splint rigidity assessment *in vivo* (8–10) and for tooth mobility evaluation during follow up after dento-alveolar trauma (8, 22, 27). The question has been raised of whether the results of the static and dynamic assessment techniques correlate or if they provide different information regarding *in vitro* splint rigidity evaluation.

The aim of this study was to compare two tooth mobility measuring methods, one static (the universal testing machine) and one dynamic (the Periotest), used for *in vitro* splint rigidity evaluation. The methods were assessed in terms of intraserial reproducibility and correlation. We investigated the following null hypotheses: (i) Three repeated measurements are not significantly different; (ii) the two measuring methods correlate within one test dimension; and (iii) the vertical and horizontal values correlate within one test method. Finally, if a positive correlation were to be identified, a conversion factor between the two methods would need to be calculated.

Materials and methods

Figure 1 schematically illustrates the splint rigidity evaluation procedure including tooth mobility adjust-

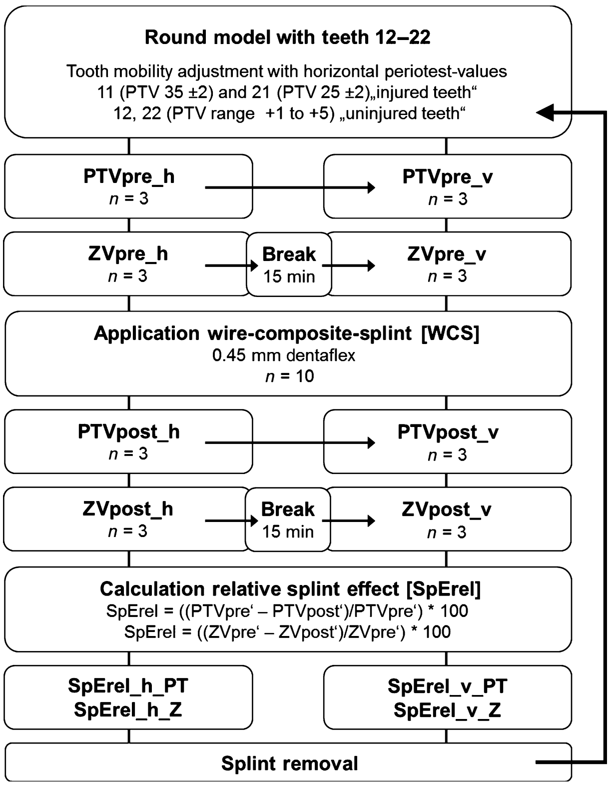

Fig. 1. Flow chart for the testing procedure. PTVpre was measured before ZVpre. After splint insertion, the PTVpost and ZVpost were evaluated with the splint in situ and then the splint was removed. The splint effect was calculated based on the 'pre' and 'post' splinting values (Vpre and Vpost). Z, Zwick; PT, Periotest; h, horizontal; v, vertical.

ment, splinting and rigidity assessment. A single investigator conducted all tests.

Model

For this investigation, a newly developed artificial model was used as described in detail in Berthold et al.(2). The model consists of a round aluminium base with six alveolar sockets, arranged in a half-round arc to simulate an almost naturally shaped dental arch. To allow increased tooth mobility, close to the clinical situation of injured loose teeth, the two middle sockets were enlarged. The root and the crown section of the simulation teeth were made of stainless steel. This investigation involved only the central four teeth (teeth 12–22). The two middle teeth (teeth 11 and 21) were defined as 'injured' with increased mobility while the adjacent teeth (teeth 12 and 22) served as 'uninjured' teeth with a physiological degree of loosening. Bovine tooth facets (3.5 × 10 mm) were attached to the vestibular coronal tooth surface (2) to enable use of the acid-etch technique for bonding the wire-composite splint under simulated clinical conditions. The PDL for the 'uninjured' teeth was simulated with silicon while the PDL of the 'injured' teeth was made of silicon and rubber foam (2). For fine adjusting the tooth mobility, apical screws were used. The model was placed in the model holder (2).

Tooth mobility adjustment

The tooth mobility was always set and readjusted before inserting a new splint by using the horizontal [h] Periotest values [PTVs] (Gulden, Modautal, Germany) before splinting [pre] as the reference point (2). The 'injured' tooth 11 was set at a degree of loosening III (PTV_h 35 ± 2), and tooth 21 was set at a degree of loosening II (PTV_h 25 ± 2) while the 'uninjured' teeth 12 and 22 were set at a degree of loosening 0 (PTV_h range 0–5 ± 2). The vertical [v] PTV resulted from the adjusting process.

Splinting

During the splinting, the model was attached to the model holder with the vestibular 'tooth surfaces' facing upward. For this investigation, a flexible wire-composite splint (Dentaflex 0.45 mm sixfold, straight wires; Dentaurum, Pforzheim, Germany) was selected (1, 2, 8). Ten individual splints were applied. The wire was cut to the designated length and then pulled over a mirror handle to achieve an almost half-round shape. Fine adjustment to enable passive fit to the dental arch was made using finger pressure. The enamel surface was conditioned with phosphoric acid (Total Etch, Ivoclar Vivadent, Schaan, Liechtenstein) and Heliobond (Ivoclar Vivadent) following the manufacturer's instructions. The previously passively adjusted wires were attached to the marked middle section of the tooth facets (sequence: teeth 12, 22, 11 and 22) using a flowable resin composite (Tetric EvoFlow Bleach XL, Ivoclar Vivadent).

Tooth mobility evaluation

To assure reproducible measuring points (8) for placing the tip of the Periotest hand piece as well as the rod of the universal testing machine, the middle of the vestibular surface and of the incisal edge was marked. Before splint insertion, tooth mobility was measured in the horizontal and then in the vertical dimension (sequence: teeth 12, 11, 21 and 22) first with the Periotest method [PTVpre] (Figs 2 and 3) and second with the universal

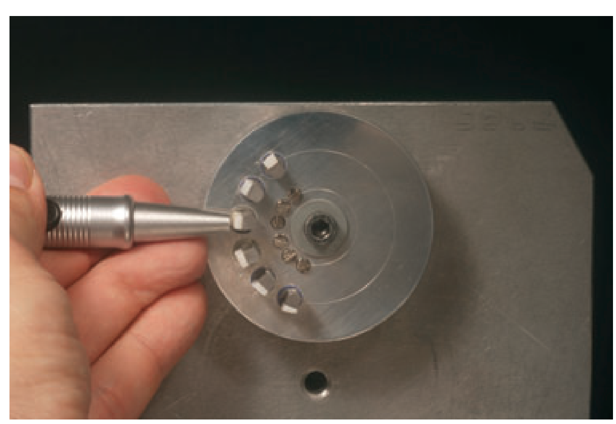

Fig. 2. The model is attached to the model holder for measuring horizontal Periotest values on tooth 21. The hand piece is horizontally levelled, and the distance between the tip and the tooth surface is about 1 mm.

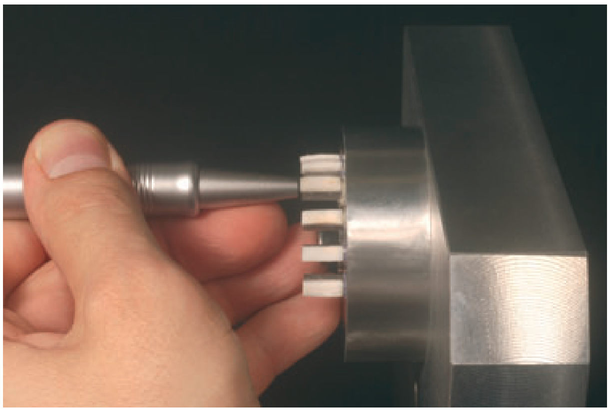

Fig. 3. The model is placed into the holder for vertical tooth mobility evaluation with the Periotest method (tooth 11).

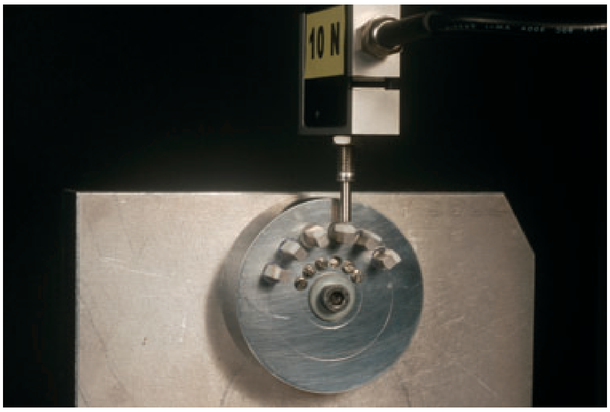

Fig. 4. The model is placed in the holder for horizontal testing with the Zwick universal testing machine. The custom-made rod is attached to the load cell and aligned with the middle part of the tooth facet.

testing machine Zwick value [ZVpre] (Zwicki 1120; Zwick, Ulm, Germany). For applying a continuous load (0–10 N, cross-head speed 2 mm min^{-1}), a custom-made stainless-steel rod (Ø 3 mm) was used (Figs 4 and 5). The load and tooth displacement were recorded using testXpert software (Zwick). Between the horizontal and vertical Zwick measurements, a pause of 15 min was included to allow resetting of the silicon PDL after the measurements.

After splint insertion, the measurements were conducted [PTVpost and ZVpost] as described earlier for the PTVpre and ZVpost, with the spilt in situ aiming at the same marked measuring points. All measurements were consecutively repeated three times per tooth, and the mean horizontal and vertical PTVs and ZVs were calculated before testing the correlation.

Splint removal

After tooth mobility evaluation, the splints were removed. The composite was reduced without touching the enamel with a diamond bur (881KS; NTI, Kahla, Germany) to allow removal of the wire. The composite remnants were ablated using a tungsten carbide bur

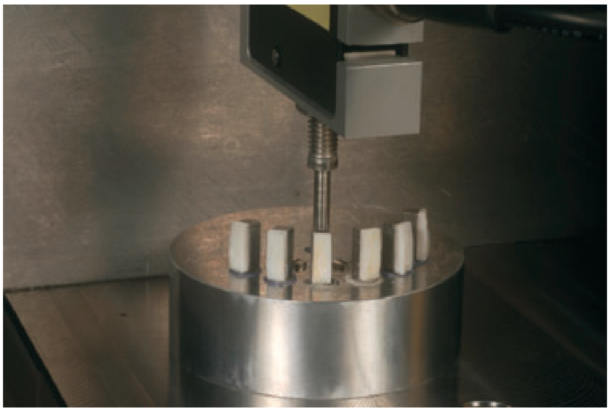

Fig. 5. The model is attached to the holder for vertical measurements with the Zwick universal testing machine. The custom-made rod is placed at the middle of the incisal edge.

(HM23R; Hager & Meisinger, Neuss, Germany) to limit enamel damage.

Relative splint effect

For calculating the splint effect relative to baseline (SpErel), the Periotest scale was adjusted from the original range (−8 to +50) to a scale with only positive values to avoid division with zero. All measured PTVs were transformed (PTV' = PTV + 9), and these PTVs were used for the SpErel calculations (2).

For calculating the SpErel in per cent, the following equations were used: SpErel_PT [%] = ((PTV'pre−PTV'post))/PTV'pre) × 100 and SpErel_Z [%] = ((ZV'pre−ZV'post)/ZV'pre)) × 100.

Statistical analysis

Descriptive analysis was performed. The results for PTVpre, PTVpost, ZVpre, and ZVpost are graphically displayed as boxplots. The means and standard deviations of PTVpre, SpErel_PT, ZVpre, and SpErel_Z are presented in tables. The Kolmogorov–Smirnov test was used to assess normal distribution. All data were normally distributed ($P > 0.05$), so parametric tests were used. Probability values <0.05 were considered statistically significant.

ANOVA was used for testing interserial reproducibility of the three consecutive measurements (M1, M2, and M3) per tooth/measuring method/dimension. If ANOVA revealed statistically significant differences ($P < 0.05$) and equality of variances was proven (Levene test; $P > 0.05$), *post hoc* tests (Bonferroni) were conducted to detect differences among the individual measurements. Spearman's rank correlation was used to test correlation for the Vpre as well as the SpErel between (a) the two test methods within one test dimension and (b) the horizontal and vertical values within one test method. Data were recorded using acquisition sheets and transferred to IBM SPSS Statistics 19.0 (IBM Corp., Somers, NY, USA). Statistical analysis was performed using the R Project for Statistical Computing (version 2.11.1; R Development Core Team 2010, http://www.r-project.org).

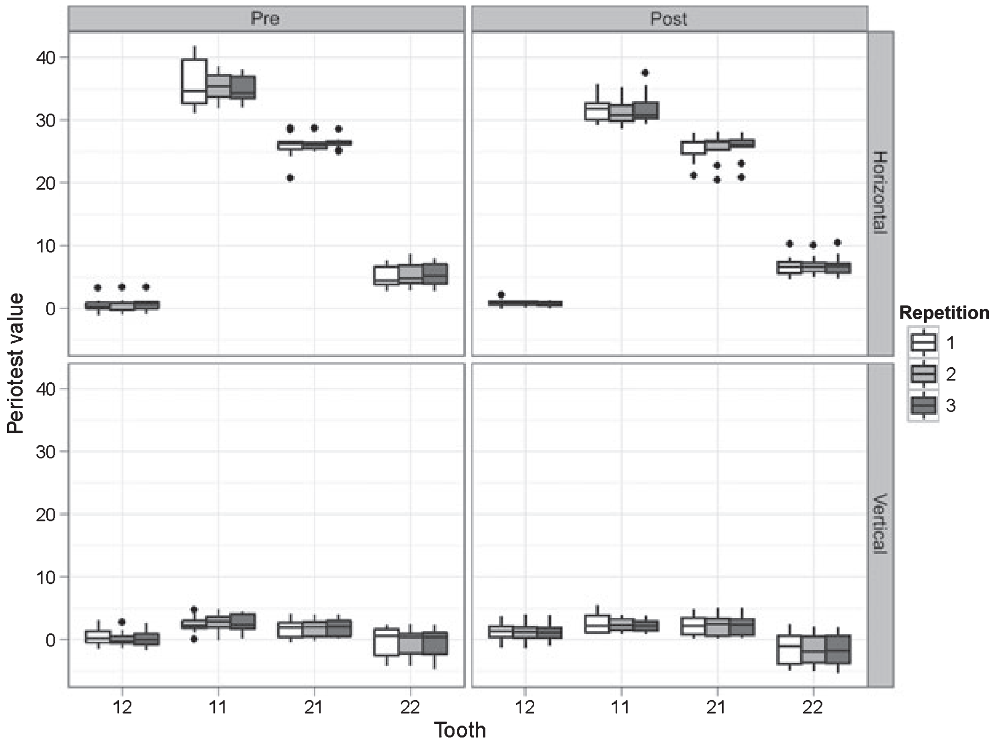

Fig. 6. Boxplot images of the three consecutively repeated horizontal and vertical Periotest measurements before (pre) and after splinting (post) for the 'injured' teeth 11 and 21 and the 'uninjured' teeth 12 and 22. The box (IQR, interquartile range) represents the 25–75th percentiles, and the whiskers show the minimum and maximum, except for outliers (dots = 1.5 times of the IQR).

Results

We recorded 960 tooth mobility values in total, 480 for each measuring method. The three repeated values before and after splinting per measuring method, dimension and tooth (Figs 6 and 7) were averaged. Calculations for the correlation test were based on the resulting mean.

Intraseries reproducibility

When testing the repeated horizontal and vertical Periotest values before (PTVpre) and after splinting (PTVpost) with ANOVA, we found no statistically significant differences ($P > 0.05$). No statistically significant differences were found within the vertical Zwick measurements ($P > 0.05$) either, but statistically significant differences ($P < 0.05$) did emerge in the horizontal ZVpre for 'injured' teeth 11 and 21 and in ZVpost for 'injured' (teeth 11 and 21) as well as for 'uninjured' teeth 12 and 22 (Table 1). In these cases, a Bonferroni *post hoc* test was used to analyse the individual measurements (Table 2). Statistically significant differences were found in each comparison of M1 and M2 and M1 and M3 ($P < 0.05$) while no differences were found between M2 and M3 ($P = 1.00$).

Correlation between test methods and dimension

After averaging the three repeated measurements before splinting and the SpErel values (Table 3), we used the mean to test for correlation (Spearman's rank correlation). Testing between PTVpre/ZVpre and SpErel_PT/SpErel_Z within one dimension revealed a few random correlations ($P < 0.05$); overall, however, no correlations were found ($P > 0.05$) (Table 4). Analysis of the horizontal and vertical Vpre and SpErel within one testing method yielded no correlations ($P > 0.05$) except for tooth 11 (ZVpre) (Table 5).

Discussion

Methodological factors

In the past, different approaches for evaluating splint rigidity have been used (1, 8–11, 13, 14, 16). One of the advantages of *in vivo* investigations (8–10) with people is the presence of a natural PDL. In addition, the acid-etch technique can be used for adhesive bonding of the splint material to the tooth surface (8, 9). However, the disadvantages of assessing splint rigidity in healthy individuals include the lack of increased tooth mobility (8, 9), the risk of damaging sound enamel during splint removal (28) and the limited availability of test persons. Therefore, *in vitro* studies using various types of models have also been conducted (1, 2, 8, 11–16, 25). The advantage of artificial models is the anytime availability, the moderate intermodel variability compared to people, and the potential for intentional adjustment of tooth mobility. In addition, there is no risk of damaging sound enamel, as can happen in healthy individuals. However, the lack of an etchable surface, such as tooth enamel, has

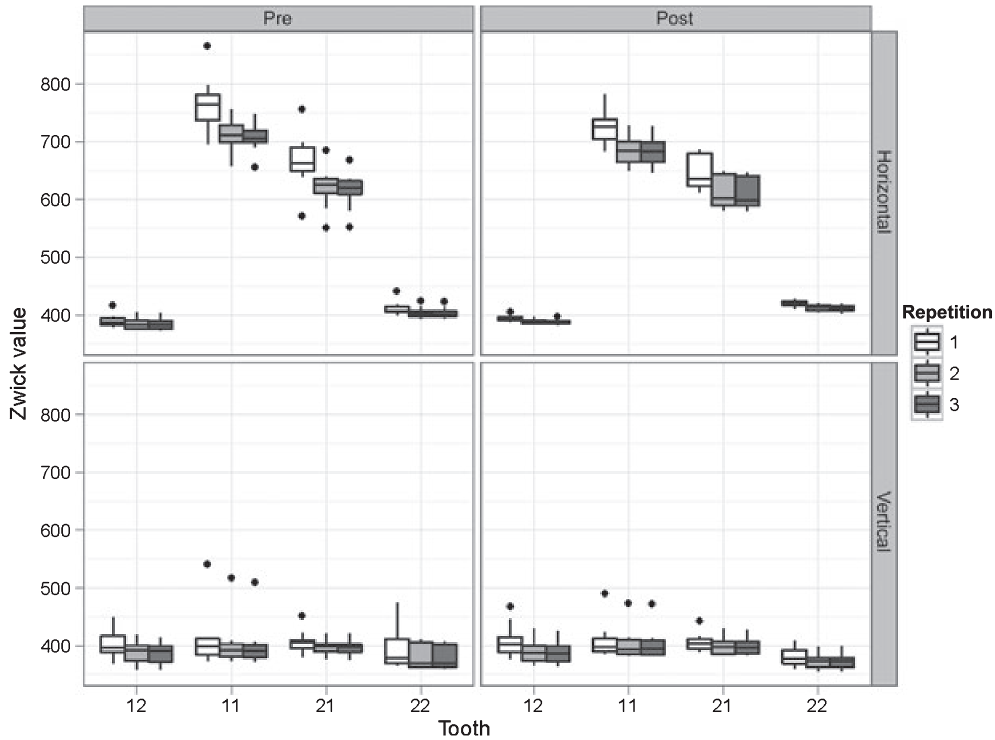

Fig. 7. Boxplot images of the three consecutively repeated horizontal and vertical Zwick measurements before (pre) and after splinting (post) for the 'injured' teeth 11 and 21 and the 'uninjured' teeth 12 and 22. The box (IQR, interquartile range) represents the 25–75th percentiles, and the whiskers show the minimum and maximum, except for outliers (dots = 1.5 times of the IQR).

Table 1. Test for intraserial reproducibility of the three consecutively repeated measurements

	d.f. 1	d.f. 2	F	ANOVA (P-value)	Levene test (P-value)
T11_ZVpre_h	2	27	8.982	0.001	0.233
T21_ZVpre_h	2	27	5.364	0.011	0.661
T12_ZVpost_h	2	27	4.837	0.016	0.895
T11_ZVpost_h	2	27	8.269	0.002	0.741
T21_ZVpost_h	2	27	5.140	0.013	0.763
T22_ZVpost_h	2	27	6.505	0.005	0.849

The data are displayed for values that yielded statistically significant differences (ANOVA; $P < 0.05$). The Levene test indicated equality of variances ($P > 0.05$).
T, tooth; ZV, Zwick value; pre, measurement before splinting; post, measurement after splinting; h, horizontal dimension.

Table 2. Test for intraserial reproducibility of the three consecutively repeated measurements

	Comparison (P-value)		
	M1_M2	M1_M3	M2_M3
T11_ZVpre_h	0.005	0.002	1.000
T21_ZVpre_h	0.038	0.018	1.000
T12_ZVpost_h	0.049	0.027	1.000
T11_ZVpost_h	0.005	0.004	1.000
T21_ZVpost_h	0.037	0.024	1.000
T22_ZVpost_h	0.019	0.009	1.000

The data are displayed for values that yielded statistically significant differences (Table 1; ANOVA $P < 0.05$). The individual measurements were compared using a Bonferroni *post hoc* test ($P < 0.05$). P-values marked in grey are statistically significant.
M, measurement; T, tooth; ZV, Zwick value; pre, measurement before splinting; post, measurement after splinting; h, horizontal dimension.

always been presented as a disadvantage of resin models (1).

With the development of a new model consisting of bovine tooth facets, this problem was solved (2). The tooth mobility can be individually fine adjusted with apical screws. Here, for simulating the clinical situation of dislocated teeth, the alveolar sockets of teeth 11 and 21 were enlarged compared to the sockets of the teeth with physiological mobility (teeth 12 and 22). In addition, the PDL of the 'injured' teeth consisted of rubber foam in the cervical and middle part of the root to simulate ruptured PDL fibres and haematoma within the PDL, mimicking the conditions of an injured PDL (8). The PDL of the 'uninjured' teeth was made of silicon to provide elastic properties for simulating the fibre apparatus of the PDL (1, 2, 11).

Splinting the teeth after dislocation injuries should prevent accidental ingestion or inhalation of the loosened tooth. It also should protect the tooth and surrounding tissues against traumatic forces during the vulnerable healing period and, at the same time, allow transmission of functional forces to support PDL regeneration (1, 2, 7–9). Flexible splints such as the wire-composite splint used in this study (1, 8) fulfil these requirements.

Table 3. Mean and (standard deviation) of the averaged three measurements before splinting and after calculation of the relative splint effect for teeth 12–22

	Tooth 12	Tooth 11	Tooth 21	Tooth 22
ZVpre_h (μm)	386.5 (10.1)	728.6 (42.5)	634.7 (44.3)	406.5 (10.5)
ZVpre_v (μm)	392.8 (21.2)	404.4 (42.1)	401.2 (16.25)	386.0 (26.9)
PTVpre_h	0.6 (1.1)	35.5 (2.8)	26.2 (1.6)	5.2 (1.8)
PTVpre_v	0.2 (1.3)	2.6 (1.4)	1.8 (1.5)	−0.5 (2.3)
Z_SpErel_h (%)	−1.1 (2.3)	4.1 (4.1)	1.4 (5.2)	−2.1 (2.6)
Z_SpErel_v (%)	−0.8 (4.2)	−0.4 (4.6)	0.0 (2.1)	2.4 (3.8)
PT_SpErel_h (%)	−2.4 (10.4)	8.1 (5.3)	1.7 (5.3)	−12.1 (14.3)
PT_SpErel_v (%)	−11.2 (10.8)	1.3 (7.4)	−4.4 (11.2)	11.0 (19.5)

Z, Zwick; PT, Periotest; Vpre, value before splinting; SpErel, relative splint effect; h, horizontal dimension; v, vertical dimension.

Table 4. Correlation (Spearman's rank correlation; $P < 0.05$) between Zwick and Periotest values within one dimension for teeth 12–22

	12		11		21		22	
Correlation Z/PT	CorCo	*P*-value	CorCo	*P*-value	CorCo	*P*-value	CorCo	*P*-value
Vpre_h	−0.030	0.934	0.030	0.934	0.188	0.603	0.782	0.008
Vpre_v	0.515	0.128	0.903	0.000	0.766	0.010	0.770	0.009
SpErel_h	−0.394	0.260	0.091	0.803	−0.127	0.726	0.248	0.489
SpErel_v	0.430	0.214	0.709	0.022	0.430	0.214	−0.103	0.777

P-values marked in grey are statistically significant.
CorCo, correlation coefficient; Z, Zwick; PT, Periotest; Vpre, value before splinting; SpErel, relative splint effect; h, horizontal dimension; v, vertical dimension.

Table 5. Correlation (Spearman's rank correlation; $P < 0.05$) between vertical and horizontal values within one measuring method for teeth 12–22

	12		11		21		22	
Correlation h/v	CorCo	*P*-value	CorCo	*P*-value	CorCo	*P*-value	CorCo	*P*-value
PTVpre	−0.176	0.627	0.442	0.200	0.297	0.405	−0.030	0.934
ZVpre	0.139	0.701	0.636	0.048	−0.024	0.947	0.042	0.907
PT_SpErel	−0.273	0.446	0.224	0.533	0.479	0.162	0.152	0.676
Z_SpErel	0.127	0.726	0.127	0.726	−0.539	0.108	0.139	0.701

P-values marked in grey are statistically significant.
CorCo, correlation coefficient; Z, Zwick; PT, Periotest; Vpre, value before splinting; SpErel, relative splint effect; h, horizontal dimension; v, vertical dimension.

For evaluating splint rigidity, objective tooth mobility assessment is required. The Periotest method is well established in dental traumatology as a tool during follow-up diagnostics of traumatized teeth. In addition to the horizontal measurements recommended for diagnostics in periodontology (29, 30), vertical measurements provide valuable additional information in trauma cases. They can be used for early detection of ankylosis (reduced PTV) and infection-related resorptions (increased PTV) and for monitoring tooth mobility during and after the splinting period (8, 27, 31). Based on the principle of dynamic testing, the Periotest device evaluates the damping characteristics of the PDL by quantifying the contact time of the tapping rod (8 g, velocity 0.2 m s^{-1}) from the beginning until the end of the tooth deflexion (32). In addition to the deflexion distance, complex factors such as the elastic properties of the PDL influence the results (33, 34).

Various *in vitro* (1, 2, 15, 16, 25) and *in vivo* (8–10) studies have used the Periotest method for splint rigidity evaluation. Other investigations focussing on splint rigidity used static tooth mobility assessment techniques such as universal testing machines (11–13). In these studies, the teeth were deflected by loads between 0 and 95°N at different angles (10–45°). In our study, we loaded the teeth horizontally and vertically (Zwick universal testing machine) at the same measuring points used for the Periotest method. The maximum load was set at 10°N in both dimensions. The relatively low force was chosen after the results of a pilot study indicated deformation of the model base when using higher forces. The software of the testing machine records the load and displacement of the tooth. Influencing factors such as the elastic properties of the PDL are negligible. After earlier studies with the Periotest device revealed a correlation between subjectively evaluated, increased tooth mobility (degree of loosening) and the deflexion (8, 35, 36) caused by the Periotest device, we suspected a possible correlation between the Periotest and Zwick values.

Study outcome

Statistical analysis revealed high intraserial reproducibility for the three consecutively repeated measurements per tooth before and after splinting in the horizontal as well as in the vertical directions. In addition to the features of the Periotest device itself, these results could be explained by the use of reproducible measuring points (8). In addition, the hand piece was kept in place for the three repetitions, and all measurements were taken by one experienced operator. The findings of this *in vitro* study are consistent with our previous *in vivo* observations on healthy volunteers (8).

While the Periotest method revealed highly reproducible results for all tests, some significant differences between the first and subsequent two measurements were found for the horizontal Zwick values. The affected teeth were the 'injured' teeth (11 and 21) when measuring before splinting (ZVpre_h) (Tables 1 and 2). For deflecting the teeth, a load of 10°N was applied. In the case of the 'injured' teeth, the resetting properties of the PDL were lower because the middle and the coronal part consisted of rubber foam, compared to the 'uninjured' teeth with a full silicon PDL. The denser silicon accumulates more energy than the porous rubber foam after deformation caused by the tooth deflection. Therefore, the time required for resetting of an 'injured' tooth to its original position was longer than for an 'uninjured' tooth. The second and third measurements followed the initial deflection within a few seconds. As a result, the expansion process of the rubber foam to regain the original tooth position was presumably not completed. The remaining deflecting distance was shorter for the second and third measurements. Therefore, the second and third measurements were significantly different compared to the first measurement.

After splinting, we found the same differences between the first and the two subsequent horizontal Zwick values (ZVpost_h) for all four teeth (Tables 1 and 2). It can be assumed that the resetting of the 'uninjured' teeth with the full PDL was altered and delayed by the wire and its deformation. The resetting time was therefore prolonged compared to the un-splinted teeth, causing the observed difference.

No significant differences were detected among the three measurements within the vertical Zwick values before and after splinting. The teeth were loaded at the incisal edge, resulting in an axial deflexion. Therefore, the resetting of the teeth was predominantly influenced by the elastic properties of the silicon, which covered the entire root in the case of the 'uninjured' teeth and the apical root third of the 'injured' teeth. The influence of the rubber foam in the middle and cervical root areas of the 'injured' teeth seemed to be negligible.

With the testing of the Periotest and Zwick values before and after splinting and per dimension, only a few random statistically significant correlations were detected (Table 4). This finding implies that the two measurement methods do not correspond. We observed similar results in our *in vivo* study (37), in which the values of the static photogrammetry method (38) did not correlate with the Periotest values (dynamic method). The principles for tooth mobility evaluation differ between the Periotest device and the Zwick universal testing machine. In the case of the Periotest method, the tapping rod of the hand piece deflects the tooth. The load is specified as 8 g at a velocity of 0.2 m s^{-1} (32). For tooth mobility assessment, the contact time from the beginning of the deflection until the end is measured. The outcome is influenced by the deflection distance as well as by the visco-elastic properties of the PDL *in vivo* (33, 34) or the elastic characteristics of the simulation PDL material *in vitro* (2). In contrast, the continuously applied load (cross-head speed 2 mm min^{-1}) with the universal testing machine was set at 10°N. During the load, the PDL was compressed and the deflection distance was recorded as a tooth mobility equivalent. Other parameters were not taken into consideration. We hypothesized that the deflection caused by low forces, as generated with the Periotest device, ranged within the simulation PDL (35) while the forces applied with the Zwick universal testing machine caused deflections up to the alveolar socket walls. Therefore, further investigations must be conducted with lower forces that are close to the Periotest method to evaluate possible correlations between the two methods under these testing conditions.

Also of interest was testing the horizontal and vertical measurements within one test method in terms of correlation. Except for one random significant correlation, all other measurements revealed no correlation. Therefore, the horizontal and vertical values of the Periotest and Zwick methods do not correspond (Table 5).

Conclusion

Within the limitations of this *in vitro* investigation, the Periotest method provided highly reproducible results for the vertical and horizontal repeated measurements before and after splinting. The results could be positively influenced by the fact that reproducible measuring points were used and only one examiner conducted the testing. The reproducibility was also high for the vertical Zwick measurements while significant differences were found within the horizontal measurements, presumably caused by the deformation of the simulation PDL after the first measurement.

A comparison of the two measuring methods within one testing dimension yielded only a few random correlations. The vertical and horizontal values within one testing method also did not correlate. Therefore, within the protocol of this particular study, the conversion of Periotest values into metric displacement data and the conversion of vertical into horizontal values are not feasible.

Taking all these facts into consideration, the Periotest and Zwick methods provide reproducible results. However, they reveal different, valuable information about tooth mobility. The Periotest method mainly describes the damping characteristics of the simulation PDL caused by small forces. In contrast, the Zwick method provides quantitative metric information about tooth mobility.

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