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# Tooth mobility changes subsequent to root fractures: a longitudinal clinical study of 44 permanent teeth

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**Abstract** – The purpose of this study was to analyze tooth mobility changes in root-fractured permanent teeth and relate this to type of interfragment healing (hard tissue healing (HT), interfragment healing with periodontal ligament (PDL) and nonhealing with interposition of granulation tissue (GT) because of pulp necrosis in the coronal fragment. Furthermore, the effect of age, location of the fracture on the root, and observation period on mobility values was analyzed. Mobility values were measured for 44 of 95 previous reported root-fractured permanent incisors. Mobility changes were measured with a Mühlemanns periodontometer and noninjured incisors served as controls. The mobility values represented the labial-lingual excursion of the root measured in $\mu$m when the tooth received a frontal and a palatal impact of 100 g force. In 18 cases of *hard tissue healing* (HT), a slightly increased mobility was seen after 3 months and 1 year, and a normalization of mobility value was usually found after 5 and 10 years. In 17 cases of *PDL healing*, generally a higher mobility was found in comparison with root fractures healing with hard tissue, and a consistent decrease in mobility value was found in the course of the 10 year observation period. A tendency for reduced mobility over time was found, a relation that could possibly be explained by the known general decrease in tooth mobility with increasing age. Finally, nine cases of *nonhealing* with initial interposition of granulation tissue (GT) because of pulp necrosis in the coronal fragment resulted in increasing mobility values possibly related to a lateral breakdown of the PDL in relation to the fracture line. In control teeth, a lowering of mobility was found over the course of a 10-year observation period. In conclusion, mobility changes appeared to reflect the radiographic healing stages and known age effects upon tooth mobility.

Periodontometry has been developed with the purpose to quantitatively register the extent of mobility of the tooth in its socket. This tool has successfully been used to assess the actual mobility values of teeth in cases of traumatic occlusion and of bone reduction in relation to marginal periodontal disease and orthodontic movement (1, 2). Furthermore, mobility changes subsequent to tooth replantation have been monitored to reflect stages and types of healing (3). Various instruments have been used to measure tooth mobility changes. The mobility instrument, designed by Mühlemann in 1960, is based on a direct measurement of the labio-lingual excursion of a tooth subsequent to given horizontal load (usually 100 or 500 g) (Fig. 1). A more indirect method of measuring tooth mobility has been the so-called Periotest® (Medizintechnik Gulden e. K., Modautal, Germany) where the dampening effect of a vibration signal applied to the crown via a probe is recorded. A comparative analysis of these two methods of recording mobility changes (excessive because of loss of periodontal support of diminished due to ankylosis) has shown a reasonably good correlation between these two types of measurements (4). A known immediate consequence of a root fracture is increased mobility with augmented values the closer the fracture line comes to the cervical margin (5). When healing takes place, the abnormal mobility becomes reduced or normal according to the type of healing. Healing with interposition of hard tissue (HT) results in normal mobility, and healing with interposition of periodontal ligament (PDL) in the fracture line results in increased mobility values (5). Finally, nonhealing owing to an infection in the coronal pulp has been found to be related to excessive loosening because of the breakdown of the lateral periodontium. (5). These above-mentioned changes described according to fracture types and type of healing all represent subjective clinical evaluations of mobility and has not so far been reported based on objective mobility testing. In a previously reported clinical long-term study of 95 fractured human permanent incisors, healing was primarily monitored radiographically but also clinically using a Mühlemann periodontometer to analyze changes in tooth mobility at various stages and types of healing (6). The purpose of the present study is to report in more details changes in tooth

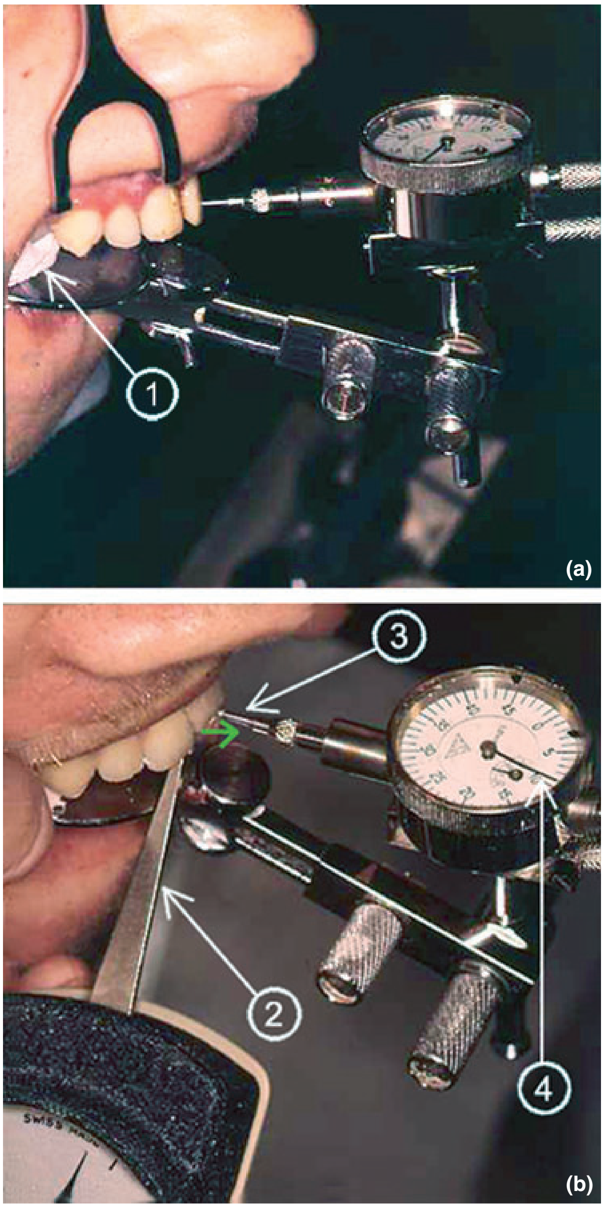


*Fig. 1.* Mobility testing using a Mühlemann's testing instrument. (a) The device is fastened to the premolar regions with a special gipsum compound (Gipsogum® Associated Dental Products, Swindon,UK) (Arrow 1). (b) A Newtonmeter directed at the lingual surface of the tooth directs a 100 g force in labial direction (Arrow 2). The resulting labial excursion of the tooth (Green arrow) is transferred via the pointer (Arrow 3) to the indicator (Arrow 4). A similar force applied to the labial surface of the test tooth gives the total horizontal excursion in hundreds of mm.

mobility as it relates to *type of healing, location of the fracture, patient age* and *observation period*, information which may be relevant to the estimation of long-term behavior of the root-fractured tooth.

## Material and methods

The material consisted of records from 85 patients treated for horizontal root fractures involving 95 incisors. These patients were followed with observation periods up to 11 years. Details concerning this material have been reported in a previous report (6, 7). This study showed a generally good long-term prognosis for root-fractured teeth and a strong connection between healing complications in relation to the extent and location of the fracture and the stage of root development. In 44 of these teeth, mobility testing was performed.

The periodontometer used was a modified macroperiodontometer (Sneholt & Nielsen A/S, Blegdamsvej 60, Copenhagen, Denmark) as devised by Mühlemann (1, 2). An impression tray with a dual indicator was fixed in the mouth with plaster of paris (Fig. 1). The pointer of the periodontometer was oriented perpendicular to the labial surface of the tooth to be measured. The indicator was placed 2 mm from the incisal edge and at equal distance from the mesial and distal side of the tooth. The labial and palatal deflection was made with a dynamometer. The tooth under examination was pushed by the dynamometer from its rest position into a labial and later palatal position by 100 g force. The excursion was indicated in mm $\times 10^{-2}$. Three readings were made in each case, and the average of the combined labial and lingual excursions was calculated as the mean mobility for the tooth examined. In each case, a noninvolved incisor and, if possible, a contralateral incisor were used as a control tooth. All readings were carried out between eight in the morning and noon. Mobility testing was carried out at the following intervals after 3 months, 1 and 5 years, and 10 years. Not all patients were controlled at 10 years. The precision of the mobility testing procedure was determined from 12 double determinations of mobility readings performed with a 24-h interval. The precision was calculated from the formula:

$$\mathrm{s}\ (\mathrm{i}) = \sqrt{\frac{\sum (d)^2}{2n}}$$

where d is the difference between duplicate registrations and n is the number of registrations. The precision of the mobility testing was found to be 0.018 mm (3, 16).

The clinical and radiographic parameters registered were the age of the patient and location of the fracture (cervical, mid-portion, or apical part of the root). The healing types examined were hard tissue healing (HT), periodontal ligament interposition (PDL), or granulation tissue related to coronal pulp necrosis (GT) (6, 7). The observation period was analyzed in relation to mobility changes. Finally, in the four observation times for each healing group, mobility values for root-fractured teeth were compared with mobility values for control teeth using an SPSS (IBM Corporation, Somers, NY, USA) 18.00 independent-samples *T*-test where unequal variance is assumed.

## Results

### Root-fracture healing types

*Healing with HT*

Healing with HT was found radiographically in 18 cases, and a flow diagram illustrates the observed mobility

*Table 1.* Mobility values related to healing outcome and observation period

| | | Healing type | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Hard tissue | | | | Connective tissue | | | | Granulation tissue | | | | |
| | | Location of root fracture | | | | Location of root fracture | | | | Location of root fracture | | | | |
| | | Apical | Middle | Cervical | Total | Apical | Middle | Cervical | Total | Apical | Middle | Cervical | Total | Control teeth |
| 3 months | Number | 3 | 6 | 4 | 13 | 2 | 8 | 3 | 13 | 1 | 3 | 1 | 5 | 18 |
| | Mean | 86 | 91 | 77 | 85 | 107 | 148 | 201 | 154 | 191 | 270 | 93 | 219 | 62 |
| | Range | 76 | 108 | 55 | 118 | 67 | 130 | 43 | 150 | 0 | 185 | 0 | 277 | 105 |
| | Standard deviation | 41 | 39 | 24 | 33 | 47 | 51 | 22 | 52 | – | 93 | – | 102 | 29 |
| 1 year | Number | 6 | 7 | 5 | 18 | 3 | 11 | 3 | 17 | 1 | 7 | 1 | 9 | 26 |
| | Mean | 89 | 70 | 77 | 78 | 94 | 153 | 282 | 165 | 96 | 171 | 66 | 151 | 57 |
| | Range | 106 | 55 | 88 | 113 | 20 | 292 | 5 | 292 | 0 | 379 | 0 | 394 | 85 |
| | Standard deviation | 39 | 20 | 33 | 30 | 11 | 97 | 3 | 97 | – | 130 | – | 119 | 21 |
| 5 years | Number | 5 | 6 | 4 | 15 | 3 | 11 | 3 | 17 | 1 | 7 | 1 | 9 | 24 |
| | Mean | 59 | 43 | 49 | 50 | 79 | 131 | 224 | 138 | 100 | 135 | 110 | 128 | 46 |
| | Range | 65 | 15 | 36 | 65 | 45 | 420 | 227 | 420 | 0 | 146 | 0 | 146 | 60 |
| | Standard deviation | 27 | 6 | 15 | 18 | 23 | 116 | 115 | 110 | – | 63 | – | 56 | 14 |
| 10 years | Number | 5 | 4 | 1 | 10 | 2 | 6 | 1 | 9 | 0 | 5 | 1 | 6 | 18 |
| | Mean | 37 | 43 | 60 | 42 | 68 | 77 | 60 | 73 | – | 78 | 153 | 90 | 40 |
| | Range | 50 | 50 | 0 | 50 | 5 | 50 | 0 | 50 | – | 96 | 0 | 113 | 49 |
| | Standard deviation | 19 | 23 | – | 19 | 4 | 22 | – | 19 | – | 39 | – | 46 | 15 |

changes as they related to observation period (Table 1 and Fig. 2). The general finding was that mobility was slightly elevated after 3 months ($P = 0.051$) and 1 year ($P = 0.014$) but was normalized after 5 years. At this point, the mean mobility values of teeth healed with hard tissue was 50 mm $\times$ $10^{-2}$ and the mean mobility of control teeth was 46 mm $\times$ $10^{-2}$ and thus no significant difference between the two could be proven at this point ($P = 0.44$).

*Healing with PDL (CT)*

Altogether, 17 cases were analyzed and all cases showed augmented mobility values, which later became reduced. However, all cases maintained augmented and significantly higher mobility values compared to non-affected control teeth at the four observation times (3 months: $P < 0.001$, 1 year: $P < 0.001$, 5 years: $P = 0.003$, 10 years: $P < 0.001$). With increasing observation periods, a slow but steady reduction in mobility took place (Fig. 3). When looking at the extent of augmented mobility in relation to location of the fracture line, too few cases had horizontal root fractures in the apical and cervical region to allow an analysis (Table 1). As expected, mid-root and especially cervical fractures had the largest mobility values (Table 1).

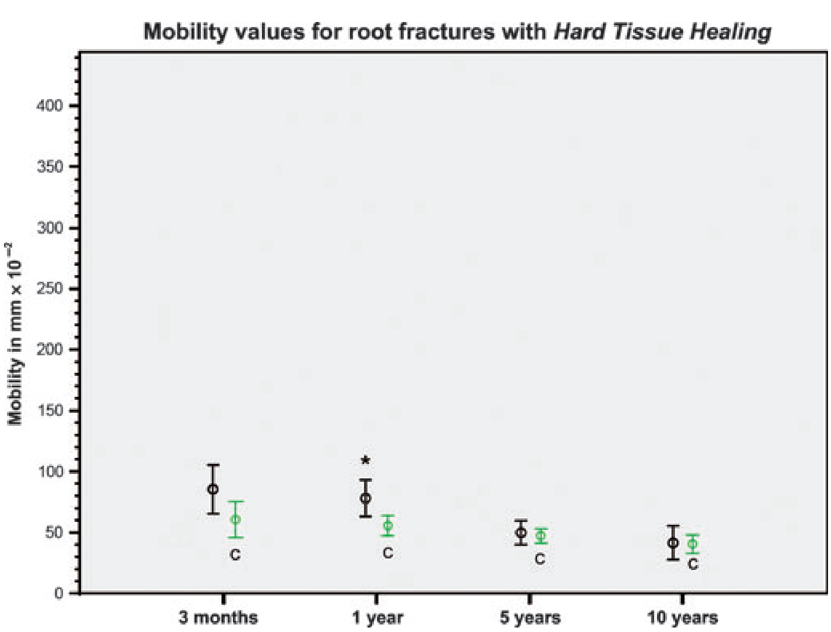


*Fig. 2.* Mobility values for root fractured teeth with hard tissue healing and control teeth within a 10 year observation period. Designation of significance level $*P \leq 0.05$; $**P \leq 0.01$; $***P \leq 0.001$.

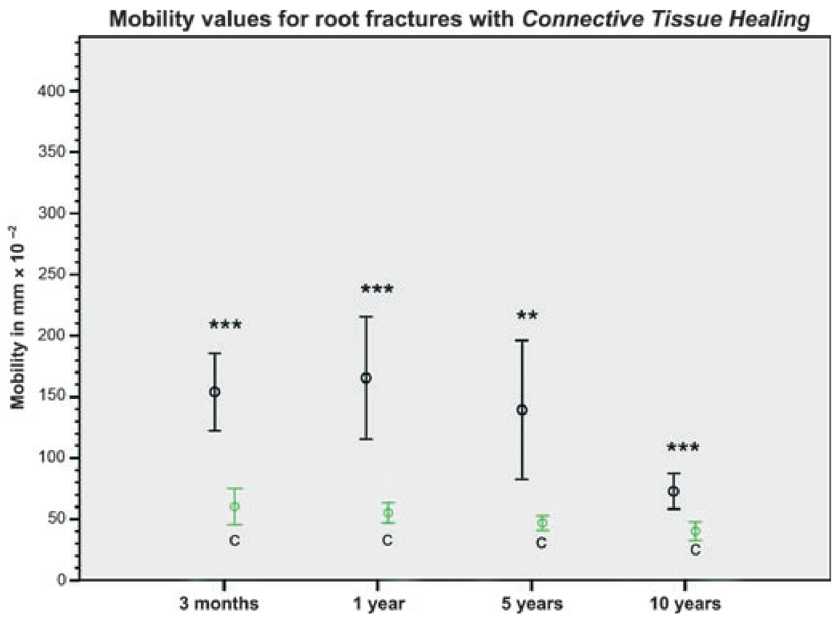


*Fig. 3.* Mobility values for root fractured teeth with connective tissue healing and control teeth within a 10 year observation period. Designation of significance level $*P \leq 0.05$; $**P \leq 0.01$; $***P \leq 0.001$.

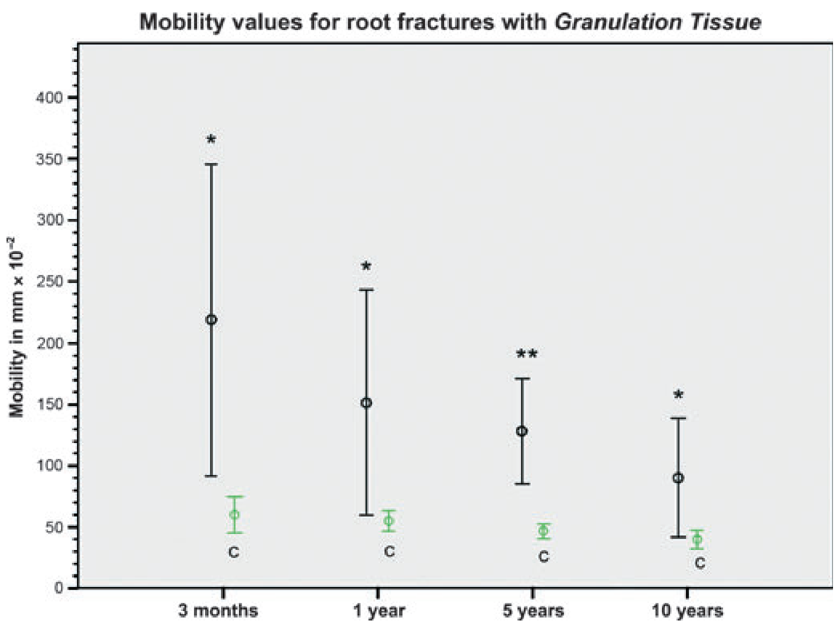


*Fig. 4.* Mobility values for root fractured teeth with granulation tissue and control teeth within a 10 year observation period. Designation of significance level $*P \leq 0.05$; $**P \leq 0.01$; $***P \leq 0.001$.

*Nonhealing with GT*

Nine cases were examined, and all cases showed stable but significantly augmented mobility values with decreasing values over time (3 months: $P = 0.026$, 1 year: $P = 0.045$, 5 years: $P = 0.002$, 10 years: $P = 0.045$). All cases were endodontically treated when nonhealing was diagnosed. Thereafter, mobility values approached healing with PDL (CT) (Fig. 4).

#### Age of patient

In Fig. 5 and Table 1, the development of mobility was illustrated for the control teeth. It appears that a general decrease in mobility took place over time with increasing age.

Further statistical analysis including variables such as type of tooth, root development, type of fixation, and antibiotics was not found to be realistic because of the limited number of cases.

## Discussion

As monitored with the Mühlemann test, mobility changes reflected rather precisely the radiographic healing pattern. From a study of avulsed and replanted human incisors, it is known that a severed PDL under optimal healing condition may heal after 4 weeks (3). In the present study, the general splinting time was 3 months, a procedural event that prevented immediate mobility testing. In regard to healing with HT, the

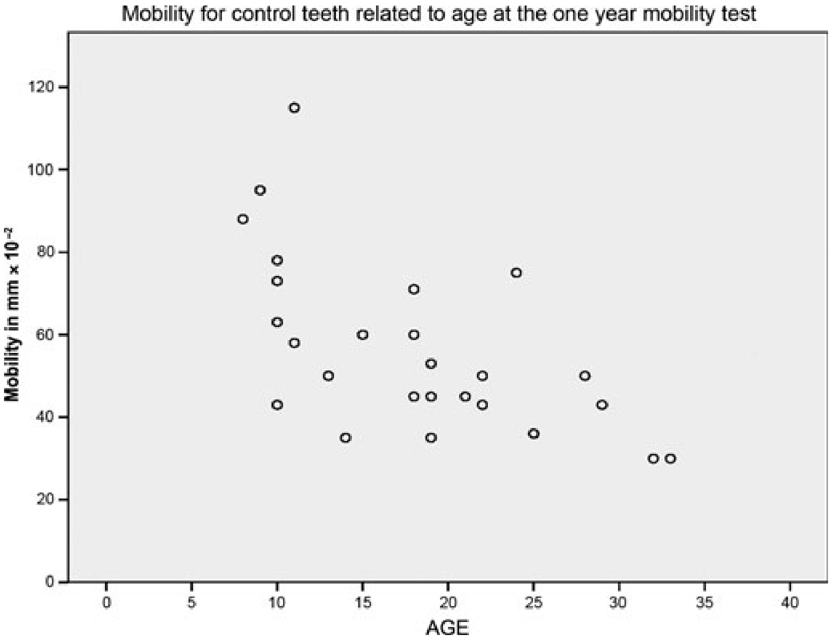


*Fig. 5.* Mobility values for control teeth at the 1 year control at various patient ages.

mobility test showed normal or next to normal values, a phenomenon that possibly reflect the fact from experience from animal experiments that HT healing only takes one to two months to establish (9). Soft tissue healing of the fracture with PDL interposition (CT) showed persisting mobility augmentation as expected in relation to fracture location. A slight lowering in mobility values was found with increasing observation periods, a finding that possibly reflects the fact that the mobility values of teeth under normal conditions decrease with increasing age (1).

Another fact may be the initial augmented mobility may have invited to more Sharpey's fiber insertion per square mm root surface, a finding that seem to operate in the PDL in case of reduction in marginal bone support because of periodontitis (10). This finding indicates that horizontal root fractures with interposition have a good long-term prognosis in relation to mobility.

Nonhealing with GT showed the expected added mobility. This finding possibly reflects the breakdown of the PDL next to the fracture line (5, 8, 11–15). All these cases were endodontically treated and continued to obtain lower mobility values again, a finding indicating a good long-term prognosis.

In conclusion, mobility changes of a root-fractured tooth appeared to reflect the healing events taking place between the fracture surfaces. The clinical relevance is that augmented mobility immediately after splint removal will gradually be diminished. In case of hard tissue healing over time, they become as firm as neighboring nonfractured teeth.

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