

# Periodontal Debridement with Sonic and Ultrasonic Scalers

Gregor J. Petersilka, Thomas F. Flemmig

Biofilm and calculus removal are very important components of periodontal therapy, and a variety of instruments may be used for debridement purposes. In recent years, the application range of sonic and ultrasonic scalers in such debridement procedures has been extended to the subgingival area as slim instrument tips allowing good access to the root surfaces have been developed. Treatment using oscillating scalers offers greater patient and operator comfort, and their treatment outcomes may be as successful as with hand instruments. However, a thorough knowledge of instrument function and profound clinical skills are necessary to allow safe, efficient application of these instruments.

**Key words:** periodontal therapy, root surface debridement, sonic scaler, ultrasonic scaler, hand instrumentation, clinical results, operating systematics

## INTRODUCTION

The development of narrow, delicate instrument tips has significantly extended the application range of sonic and ultrasonic scalers (Fig. 1). The relatively large, bulky instrument tips of ultrasonic scalers previously limited the application range of these instruments to the supragingival area. Today, however, plaque and calculus can be removed efficiently even from deep and narrow pockets with power-driven instruments (Petersilka et al, 2002). Apart from enhancing patient comfort, ultrasonic and sonic scalers can now be used as an alternative to the more complicated and tiring handling of hand instruments in most cases. A critical comparison of clinical studies reveals that the therapeutic results obtained with oscillating scalers are equivalent to those of hand instrumentation (Tunkel et al, 2002). Nevertheless, power-driven instruments have to be applied with special care to avoid unnecessary damage to the hard tissue of the treated roots.

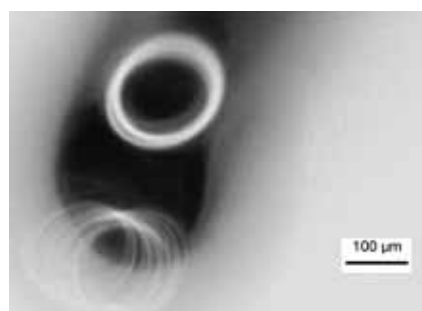
Oscillating scalers are used at various stages of periodontal therapy and – as with hand instruments – the objectives of debridement may vary from case to case. During initial therapy, a more efficient instrument should enable fast removal of the sometimes larger amounts of calculus that are firmly attached to the tooth surface. During the subsequent periodontal maintenance therapy, however, the main aim is to remove the supra- and subgingival biofilm, taking great care to minimize any damage to the hard and soft tissue. This takes into account that a patient presenting regularly for maintenance therapy will have only small amounts of supragingival calculus and no new subgingival calculus formation. In both modes of periodontal therapy, however, a thorough knowledge of the functioning of oscillating scalers, the correct application technique, and compliance with consistent working systematics are prerequisites for their safe, efficient clinical application.



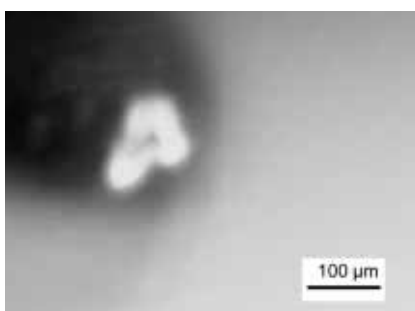
**Fig. 1** Narrow, delicate scaler tips enable efficient periodontal debridement (from left to right: periodontal probe, 3A probe, ultrasonic scaler tip).



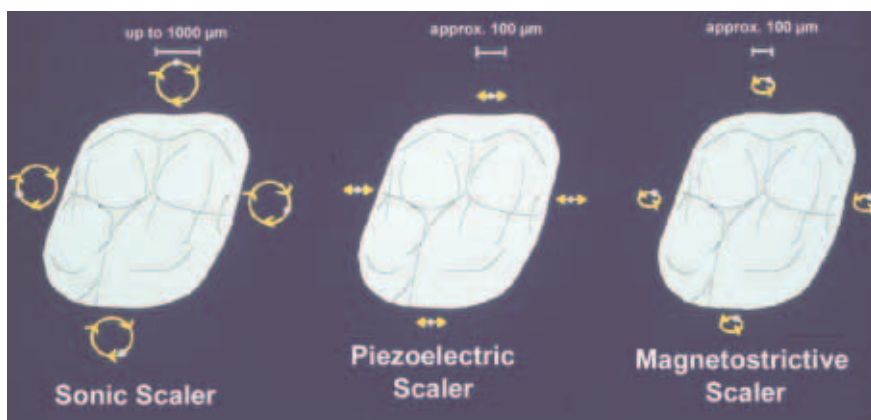
**Fig. 2** Customary sonic and ultrasonic scalers (from top to bottom: sonic scaler, insert for magnetostrictive ultrasonic scaler with stack of metal strips, insert for magnetostrictive ultrasonic scaler with ferrite rod, piezoelectric ultrasonic scaler).



**Fig. 3** Circular vibration pattern of an oscillating sonic scaler tip under undamped conditions (magnification 40X). With kind permission of Clovis M. Faggion.



**Fig. 4** Vibration pattern of an oscillating sonic scaler tip under damped conditions (1 N damping at dentin). The circular vibration pattern found under undamped conditions became polygonal. With kind permission of Clovis M. Faggion.



**Fig. 5** Schematic presentation of the vibration behavior of oscillating scaler tips: circular vibration pattern of the sonic scaler (left), linear vibration pattern of the piezoelectric scaler (middle), ellipsoidal vibration pattern of the magnetostrictive scaler (right).

### Sonic und ultrasonic scalers

In sonic scalers (e.g., Sirona Siroair, KaVo Sonicflex, W&H Synea Handpiece), the air pressure from the turbine flange of the dental unit is used to generate high frequency vibrations between 6 and 8 kHz (Fig. 2). For this purpose, a pivoted hollow cylinder within the handpiece of the sonic scaler is made to rotate by the air flow, and the resulting vibrations are conveyed to the instrument tip. The scaler tip vibrates almost circularly with an amplitude of ca. 60 to 1000 µm, depending on

the brand (Figs 3 and 4) (Menne et al, 1994). In recently developed sonic scalers, the amplitude of the vibrations of the tip can be modified and reproduced accordingly by adjusting the power on the handpiece. In addition, the vibration mode can be influenced by adjusting the turbine air pressure. Regardless of the position of the instrument tip in relation to the tooth, i.e., mesial, distal, buccal, or lingual, calculus is removed by localized hammering motions of the working end, which may be considered a potential advantage of sonic scalers over ultrasonic scalers (Fig. 5).

The difference between the ultrasonic scalers in current use is based on their magnetostrictive or piezoelectric systems for generating tip oscillation. In magnetostrictive ultrasonic scalers (e.g., Dentsply Cavitron, Odontoson M, Perio-Select), the vibrations are generated either by stacked metal strips firmly attached to the instrument tip or by a ferrite rod (Fig. 2). This ferromagnetic material is pushed into the shaft of the handpiece and is thus exposed to a changing magnetic field, causing it to vibrate at high frequency. Depending on the type of instrument, vibrations ranging from 20 to more than 45 kHz are generated, making the instrument tip vibrate in circular or ellipsoidal pattern with an amplitude of up to ca. 100  $\mu\text{m}$  (Menne et al, 1994; Trenter et al, 2003; Lea et al, 2003). Due to the mostly ellipsoidal, spatial vibrations, the instrument tip is unlikely to remove calculus uniformly and actively in all directions. Depending on how the tip is aligned, it either hits the tooth surface or passes by; this is an important criterion when applying these instruments (s. Fig. 5). In piezoelectric ultrasonic scalers, a quartz crystal is inserted into the interior of the handpiece to generate vibrations (e.g., EMS Piezon Master, Satelec P-Max, and most of the stationary ultrasonic handpieces in use at the dental unit (Fig. 2)). The quartz crystal is provided with high frequency alternating current and the bipolar structure of the quartz molecules causes it to expand or to contract and thus to vibrate. Depending on the type of instrument, the vibration frequency can reach 20 to 35 kHz. The vibration mode is mostly linear, i.e., on the same level, at an amplitude of 12 to 72  $\mu\text{m}$  (Menne et al, 1994; Lea et al, 2003). It is thus unlikely that all parts of the instrument tip remove calculus to the same extent and, depending on how the working end is aligned to the tooth surface, the pattern of calculus removal will be a merely hammering or scratching one (s. Fig. 5).

The "Vector" (Dürr Dental, Bietigheim-Bissingen, Germany) occupies an exceptional position among the piezoelectric sonic scalers. According to the manufacturer, it differs from conventional ultrasonic scalers in that the instrument tip vibrates along its longitudinal axis with an amplitude of ca. 30  $\mu\text{m}$  and a frequency of approx. 25 kHz. As the longitudinal direction of vibration probably reduces the amplitude and mechanical effect of the working end of the Vector unit compared with previous ultrasonic scalers, an abrasive medium (e.g., aqueous

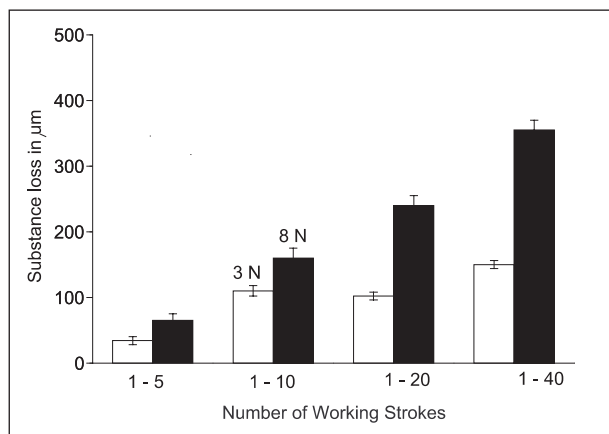
suspension of hydroxyapatite crystals) should be added to the irrigation fluid for compensation. Thus, calculus removal could be achieved by mechanical interaction of the crystals in the abrasive medium caused to flow lamarily by the vibration of the instrument tip - a technical procedure resembling so-called lapping (Braun et al, 2003).

All ultrasonic scaler systems allow power adjustment directly at the unit, thus entailing a change in amplitude but not in frequency. In sonic scalers, both the frequency and the amplitude of the instrument tip vibration are influenced by the air pressure.

### Efficiency of and damage by hand instruments and oscillating scalers

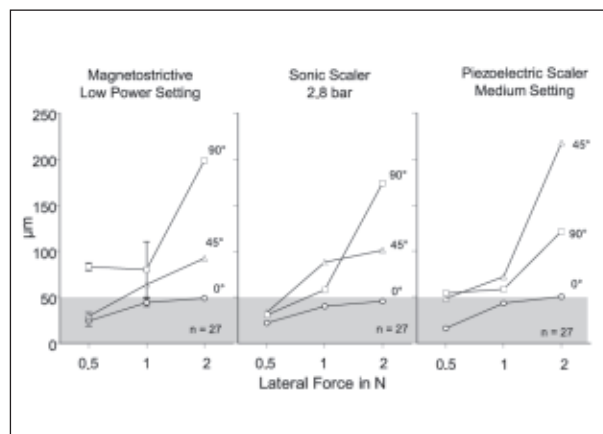
The amount of calculus to be removed and thus the handling of any instrument used in periodontal therapy must be adjusted to the individual treatment need, with substance loss being avoided as far as possible. Especially during repeatedly performed periodontal maintenance therapy, even minor damage to the root surfaces can accumulate over time to form deep defects. The mode of calculus removal with hand instruments has been extensively investigated. Defects resulting from the use of hand instruments - a sharp-edged instrument and its correct angulation are essential - depend on the number of tractions and the applied force, and can thus be easily regulated by the operator (fig. 6) (Kaya et al, 1995; Zappa et al, 1991). The working parameters time, force, angle, and instrument adjustment are the crucial factors for the correct application of sonic and ultrasonic scalers in the various forms of therapy, i.e., initial therapy and supportive periodontal therapy, so that the safety and efficiency of calculus removal may vary considerably. In vitro investigations have provided more detailed information on the impact of combinations of various working parameters in particular. For this purpose, extracted teeth were treated with sonic and ultrasonic scalers under standardized conditions with a combination of various parameters being applied, and the amount of calculus removed was quantified. Subsequently, the relative influence of various parameters on the amount of calculus removed was determined by multiple regression analysis (Flemmig et al, 1997; Flemmig et al, 1998a; Flemmig et al, 1998b).

The investigation of the sonic scaler (Sonicflex with perio tip no. 8; KaVo, Biberach, Germany) showed



**Fig. 6** Cumulative root substance loss through hand instrumentation, depending on the force applied during treatment (3 N  $\approx$  300 g, 8 N  $\approx$  800 g) (according to Zappa et al. 1992).

that surface pressure and angulation of the scaler tip had the same influence. This means that the instrument can be applied gently when the scaler tip is aligned almost parallel to the root surface, i.e., at an angle of 0°. For all powers between 0.5 and 2 N, investigations have shown that the amount of calculus removed from a tooth surface within 40 sec. and within one year of supportive periodontal therapy (Badersten et al, 1981; Badersten et al, 1984) remains below the critical value of 50  $\mu$ m (Flemmig et al, 1997) regarding substance loss. However, combinations of steeper angulations and greater force result in significant substance loss within a short time (Fig. 7, center). It has not yet been conclusively determined whether the safety and efficiency of the newly developed airscaler handpieces can be regulated and reproduced by adjusting the instrument power on the handpiece. The different movement of the investigated magnetostrictive ultrasonic scaler (Cavitron with slim-line tip; Dentsply, Konstanz, Germany) results in a variable amount of substance removal. The influence of angulation and surface pressure is about the same; at all settings, steeper angulation combined with increased lateral force in vitro soon leads to deep defects, even to perforations into the root canal (Fig. 7, left). In contrast, a higher power setting on the instrument does not cause such a pronounced increase in defect depths. Nevertheless, to avoid exceeding the critical value of 50  $\mu$ m, the power setting on the instrument must be low to medium, and absolutely parallel angulation of the



**Fig. 7** Defect depths after 40 s in vitro instrumentation with oscillating scalers, depending on angulation and surface pressure (1 N  $\approx$  100 g).

instrument tip as well as low force (<1 N) must be ensured (Flemmig et al, 1998a).

With regard to the investigated piezoelectric ultrasonic scaler (Piezon Master 400 with perio tip DS 016; EMS, Nyon, Switzerland), the amount of calculus removed is influenced primarily by the selected angulation on account of its mostly linear vibration pattern. The surface pressure appears to be of less importance, and the selected power setting on the instrument has the least influence on the amount of calculus removed. The great influence of angulation on the amount of calculus removed is reflected in the rapid increase in defect depths after a change of angulation from 0° to 45°. When the piezoelectric ultrasonic scaler was applied incorrectly, perforations of the tooth roots were seen in vitro within 40 s of treatment. However, if the instrument tip was aligned parallel to the root surface, the critical value of 50  $\mu$ m could be maintained through all possible adjustments, even with a high surface pressure of up to 2 N (Fig. 7, right) (Flemmig et al, 1998b).

### Clinical efficiency of the instrumentation procedures

Thorough sonic and ultrasonic scaling reduces the subgingival biofilm to the same extent as subgingival scaling with hand instruments (Petersilka et al, 2002). A recently performed systematic review of the clinical efficiency of different instrumentation techniques has shown that comparable attachment

**Table 1** Medium attachment gains after machine-driven debridement (MDD) and hand instrumentation (HI). PMT: Periodontal Maintenance Therapy (References 2, 3, 8, 22, 43).

Study	Treatment Phase	Statistical Analysis based on	Mean Clinical attachment Gain and Standard Deviation in Millimeters	
			HI	MDD
Badersten et al 1981	Initial Therapy	Site	0.3	0.5
Badersten et al 1984	Initial Therapy	Site	0.5	0.2
Kocher et al 2001	Initial Therapy	Subject	0.53±1.16	0.71±1.07
Copulos et al 1993	PMT	Subject	0.10±1.71	0.20±1.34

**Table 2** Medium reduction in probing pocket depth after machine-driven debridement (MDD) and hand instrumentation (HI). PMT: Periodontal Maintenance Therapy (References 2, 3, 8, 22, 43).

Study	Treatment Phase	Statistical Analysis based on	Mean Reduction in Pocket Probing Depth and Standard Deviation in Millimeters	
			HI	MDD
Badersten et al 1981	Initial Therapy	Site	1	0.5
Badersten et al 1984	Initial Therapy	Site	1.4	0.2
Kocher et al 2001	Initial Therapy	Subject	0.77±0.80	1.10±0.70
Copulos et al 1993	PMT	Subject	0.72±1.09	0.75±1.20

**Table 3** Average time needed for periodontal debridement of a tooth during initial therapy or supportive periodontal therapy (maintenance). PDD: Power-driven debridement, HI: Hand instrumentation, PMT: Periodontal Maintenance Therapy (References 2, 3, 8, 9, 24, 30, 41, 43, 46).

Study	Treatment Phase	Instrumentation Time in Minutes and Standard Deviation	
		HI	MDD
Badersten et al 1981	Initial Therapy	5.35	6.15
Badersten et al 1984	Initial Therapy	6.85	6.85
Dragoo 1992	Initial Therapy	7.55	9.6
Laurell & Petterson 1988	Initial Therapy	8.00±3.00	12.00±5.00
Moscow & Bressmann 1964	Initial Therapy	3.3	3.8
Torfason et al 1979	Initial Therapy	3	3.8
Yukna et al 1997	Initial Therapy	2.80±1.3	4.80±3.2
Badersten et al 1981	PMT	0.35	0.4
Badersten et al 1984	PMT	1.35	1.3
Copulos et al 1993	PMT	3.90±1.20	5.90±2.10
Torfason et al 1979	PMT	2.1	2.4

gains and pocket probing depth reductions can be obtained after subgingival scaling with sonic and ultrasonic as well as with hand instruments (Tunkel et al, 2002) (Tables 1 and 2). Regarding the efficiency of calculus removal in furcations of multi-rooted teeth, sonic and ultrasonic scalers allow for more efficient cleaning than hand instruments (Kocher et al, 1998; Loos et al, 1987). As combining both instrumentation modes is unlikely to lead to better clinical results, one single instrumentation mode must be generally considered suffi-

cient. In an interesting and critical review, the use of oscillating scalers proved to save more than 30% of treatment time compared with hand instrumentation (Tunkel et al, 2002). Nevertheless, up to 8 minutes or more are considered necessary for the debridement of a severely periodontally diseased tooth, e.g., during initial therapy (Table 3).

The irrigation medium needed to cool the heated scaler shank reaches the edge of the instrument tip in the pocket, preventing thermal damage to the tooth (subject to a correct evacuation technique).

Calculus and biofilm components are loosened by the mechanical action of the tip and are then flushed away from the periodontal pocket by the coolant (Nosal et al, 1991). However, a relevant additional cleaning effect of the irrigation medium in the pocket by so-called microstreaming effects or even an antimicrobial effect on periodontal pathogens by cavitation, i.e., the implosion of minute gas bubbles at the tip of oscillating scalers, has yet to be proven in vivo (Schenk et al, 2000). The use of special antimicrobial irrigants (e.g., chlorhexidine or iodine solutions) as an adjunctive irrigation medium for sonic and ultrasonic scalers does not lead to a clinically better treatment outcome (Chapple et al, 1992; Taggart et al, 1990). Therefore, water can be recommended as a coolant. Regarding the safety of oscillating scalers, it must be kept in mind that sonic or ultrasonic scalers produce a potentially infective aerosol consisting of disrupted biofilm, blood, saliva, and coolant. Antiseptic mouthrinsing prior to therapy (e.g., with chlorhexidine digluconate solution or Listerine®) as well as the correct use of high volume evacuators can substantially reduce the bacterial counts in the aerosol. However, a possible infection risk for the operator cannot be completely ruled out (Barnes, 1998). For this reason, a face mask and gloves in addition to well-fitting safety glasses should be worn when using high frequency oscillating instruments. In the treatment of patients with infectious diseases, preference should be given to the use of hand instruments (Barnes, 1998). The results of numerous studies investigating the surface structure of the root after different instrumentation modes were partially discrepant. Depending on the type of study, smoother surfaces were found after hand instrumentation (Allen, 1963; Jones et al, 1972; Kerry, 1967; Rosenberg and Ash, 1974; Van Vulkinburg, 1976) or after the use of ultrasonic instruments (Ewen et al, 1976; Moskow and Bressman, 1964; Pameijer et al, 1972). In one case, the surface morphology was found to be the same for both instrumentation modes (Lie and Meyer, 1977), and smoother (Kocher et al, 2001a), equally rough, (Loos et al, 1987) or rougher surfaces were each found once for sonic scalers compared with ultrasonic instrumentation (Van Volkinburg, 1976; Jotikashira et al, 1992). As the roughness of the root surface appears to be of little significance for periodontal healing (Oberholzer et al, 1996; Waerhaugh, 1956), the

surface morphology is of minor importance only, provided no substantial substance loss is induced at the root surface by overinstrumentation.

In terms of maximum instrumentation depth, smaller ultrasonic scaler shafts seem to produce slightly better results compared with hand instruments (Dragoo, 1992; Kawanami et al, 1988). Sonic and ultrasonic scalers are clearly superior to hand instruments with regard to furcation instrumentation (Leon and Vogel, 1987). Anatomical studies have shown that the access to furcations is mostly much smaller than the average width of the working end of hand instruments, (Bower, 1979) but that thin sonic or ultrasonic tips might succeed. Modern inserts for sonic and ultrasonic instruments are of the same dimension as those of periodontal probes, i.e., they are much smaller than conventional hand instruments. In addition, sonic and ultrasonic scalers need much less space for efficient working than do the tractions needed with hand instruments. For this reason, it appears easier to debride relatively inaccessible furcations with these modern instruments (Oda and Ishikawa, 1989). It is much more comfortable and less tiring for the operator to work with power-driven instruments, and most patients consider treatment with high frequency oscillating instruments to be more comfortable (Hartley et al, 1959). However, the successful and safe application of sonic and ultrasonic instrumentation is subject to adequate training and experience as well as to observance of consistent working systematics guaranteeing complete instrumentation of all root areas in need of therapy (Kocher et al, 1997; Kocher et al, 1998).

### Sonic and ultrasonic scaling technique

The application technique of sonic and ultrasonic scalers is fundamentally different from hand instrumentation. In most cases, efficient debridement can be achieved with contra-angularly curved scaler tips which are used for various areas of the oral cavity (Fig. 8). The respective tip is aligned to the tooth in such a way that the convex working end is in principle guaranteed to contact the root surface (Figs. 9, 10 and 11). Thus, damage caused by scratching and hitting the root surface with the edge of the tip can be avoided. The angulation in the second level of the area permits access to the root areas despite any crown prominences. The scaler tip is aligned correctly when its curvature is directed towards the tooth being treated (Fig. 12).

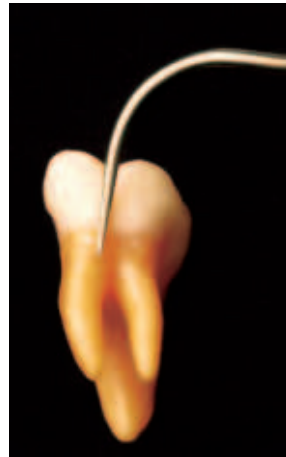




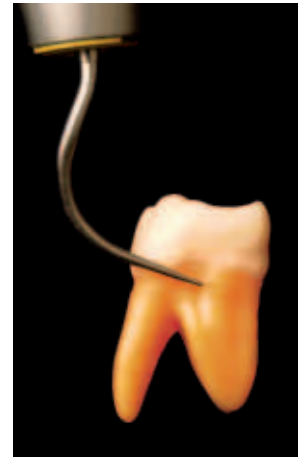
**Fig. 8** Contra-angulantly curved instrument tip (EMS, Nyon, Switzerland) for efficient debridement of the total dentition.



**Fig. 9** The instrument tip is correctly aligned when the curvature is directed towards the tooth to be treated (e.g., left-curved tip to be used in the first quadrant from the buccal aspect).



**Fig. 10** Possibilities for correct scaler tip alignment: The convex side of the shank is aligned parallel to the tooth surface and to the tooth axis, avoiding merely punctiform contact of the tip with the root.



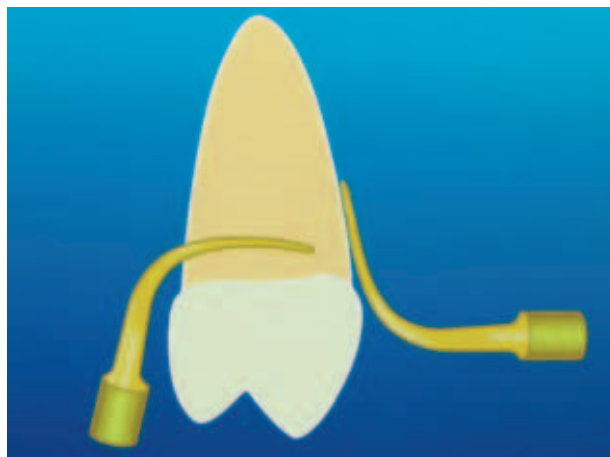
**Fig. 11** In addition, the same instrument tip (see Fig. 10) can be inserted transversely or horizontally into the interproximal area from the opposite side. However, the tip also has to be directed parallel to the treated root surface in order to prevent damage to the surface.

In clinical practice, the morphology and dimension of the gingival pocket should first be determined by careful, probing-like movements of the working end. The root surface is then cleaned systematically by continuously moving the scaler tip and performing serpentine-like, overlapping tractions (Fig. 13 and Figs. 14-17). If calculus is to be removed during initial therapy, the efficiency of the instrument can be regulated individually by selecting adequate parameter combinations. For almost exclusive biofilm removal during supportive periodontal therapy, unnecessary substance loss should be avoided as far as possible by applying a force of less than 1 N, aligning the instrument tip largely parallel to the tooth, and selecting a lower power setting (Flemmig et al, 1997; Flemmig et al, 1998a; Flemmig et al, 1998b). Supragingivally, the irrigation effect of the coolant often leads to an optically clean appearance after a short treatment time. Subgingivally, however, there will still be biofilm or calculus left in the event of unsystematic handling. As only the front edge of the scaler tip (generally ca. 1-2 mm) actively removes the biofilm or hard accretion, thorough and systematic subgingival instrumentation is of great importance. Root surface debridement with any instrumentation technique is complete when a tactilely and visibly

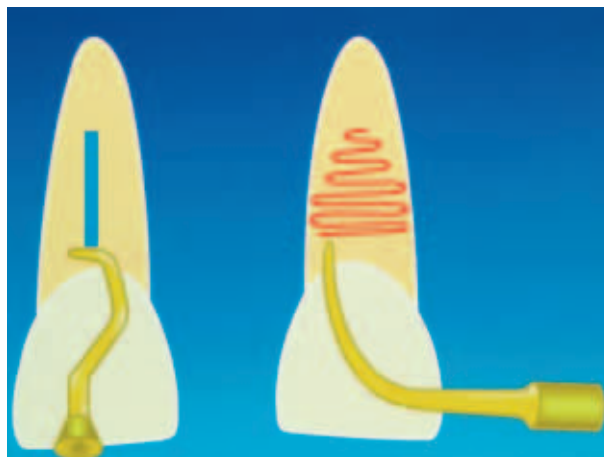
clean root surface is obtained. This can be checked with a probe and with the air flow of the air-water syringe of the dental unit.

### Working systematics

According to the shape of the currently used instrument tips, a complete dentition is divided into four areas (Fig. 18). If the tip is aligned with the correct angulation, the buccal and interdental surfaces of the first quadrant can be treated from the most distal molar to tooth 13; the same tip is used for the palatal surfaces from the canine to the last molar of the second quadrant (red line in Fig. 18). Before changing the instrument tips, the interproximal spaces can be treated efficiently from the palatal aspect with the tip initially used for the buccal surfaces, and the interdental surfaces of the teeth initially cleaned from the palatal side can be treated from the buccal aspect (see arrows in Fig. 18). After a change of instrument tips, the contralateral surfaces can first be treated from the palatal and buccal aspect and then from the interproximal space. If these systematics are observed and actually performed, thorough cleaning of all root surfaces should be ensured.



**Fig. 12** Schematic presentation of possible correct alignment techniques for ultrasonic scaler tips parallel (right) and transverse (left) to the longitudinal root axis.



**Fig. 13** Various working systematics in hand instrumentation and in sonic and ultrasonic scaling. In hand instrumentation (left) the tractions result in calculus removal from the whole surface. The relatively small contact point between scaler tip and tooth surface requires systematic cleaning by many overlapping tractions.



**Fig. 14** Clinically, a 7-mm-deep pocket is present at the mesial surface of tooth 22.



**Fig. 15** The instrument tip has been placed on the gingiva to show the instrumentation depth for demonstration purposes.



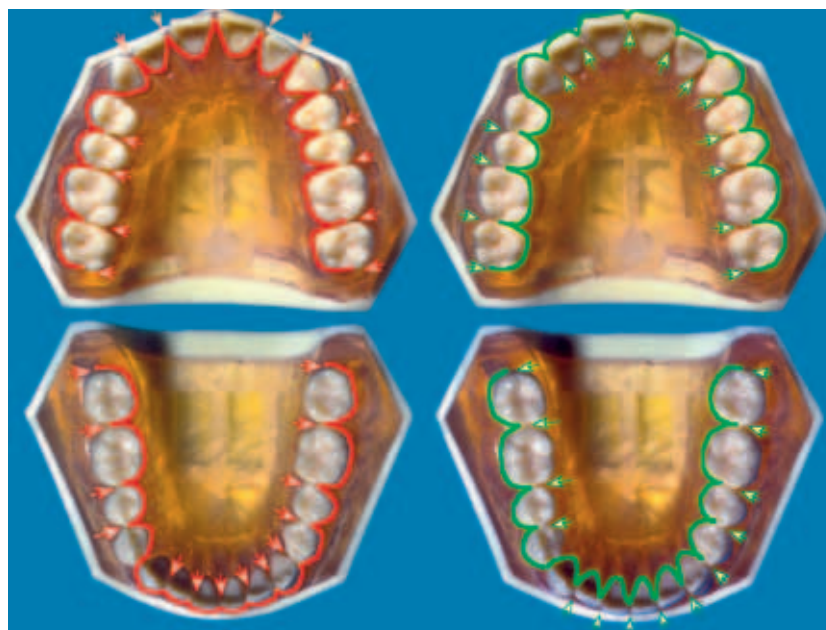
**Fig. 16** The instrument tip has been inserted into the pocket after local anesthesia and the root surface can now be cleaned as described in the text.



**Fig. 17** Four months after nonsurgical therapy, the clinical attachment gain and probing pocket depth reduction are as expected.



**Fig. 18** Working ranges of contra-angularly curved scaler tips. The working range of the left-curved scaler tip is marked in red, and that of the right-curved instrument tip in green.



#### Remark of the authors:

The present article corresponds to an updated and translated version of the publication "Subgingivales Debridement mit Schall- und Ultraschallscalern" published in *Parodontologie* (1999; 3; 233-244).

#### CONCLUSIONS

The present state of the art considers the application of sonic and ultrasonic scalers to be on par with conventional hand instrumentation. Slim instrument tips allow for more comfortable, less tiring working and for better access to previously difficult root areas, in addition to providing time savings. However, one precondition for a successful therapeutic outcome with no irreversible damage to the root surface is careful, systematic handling of these instruments. Like any other new instrumentation technique in dentistry, this has to be learned through adequate training and practice.

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#### Reprint request:

PD Dr. Gregor J. Petersilka,  
 Poliklinik für Parodontologie  
 Zentrum für ZMK des Uniklinikums Münster,  
 Waldeyerstr. 30, 48149 Münster  
 E-Mail: petersilk@uni-muenster.de