Post-treatment supportive care for the natural dentition and dental implants

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For at least the last 135 years, generations of dentists and oral health-care professionals have recommended periodic dental visits to minimize the recurrence or development of dental caries and periodontal disease (28, 97, 106, 191, 272, 289, 304, 310). The original basis for this recommendation stemmed from the clinical impression that treated patients who returned for post-treatment supportive care were more likely to keep their teeth compared with those who did not receive this care. This clinical impression has been validated by data derived from numerous longitudinal studies and clinical reports published in the past 50 years (17–19, 25, 31, 44, 54, 58, 59, 62, 70, 98, 114, 118, 120, 121, 133, 140, 144, 162, 163, 174, 183, 185, 197, 198, 201, 202, 209, 220, 229–232, 242, 258, 259, 266, 273, 284, 299–302, 321). Post-treatment supportive care, also known as periodontal maintenance therapy or supportive periodontal therapy, is clearly beneficial to patients and is an essential component of long-term successful periodontal treatment.

Successful treatment of slight and moderate forms of chronic periodontitis requires the effective teaching of oral hygiene skills, very thorough removal of supra- and subgingival biofilms (i.e. plaque and calculus) and a supportive care program. Although this sounds simple, it is not. In 1886, G. V. Black (27), who was one of the thought leaders of his generation, eloquently pointed out that successful treatment of periodontitis is difficult (see Quotation Box 1).

Oral hygiene skills

Before placing a patient on a program of supportive periodontal care, the therapist needs to make certain that the patient has mastered the oral hygiene skills that are required to minimize the recurrence of dental caries and periodontal disease. Inexperienced oral health-care workers often think that oral hygiene instructions simply involve showing patients the mechanics of how to brush and floss. Although the mechanics are important, emphasis should be placed on acquiring the required oral hygiene skills and knowing why these skills need to be practiced. For the patient, the overall goal or outcome is, of course, to be able to remove all of the clinically detectable supragingival plaque (and perhaps also some of the subgingival biofilm) without causing damage to the tissues.

Successful oral hygiene instructions involve an equal-responsibility partnership between a patient and their therapist. It is the responsibility of the oral health-care professional to make certain that the patient has acquired the oral hygiene skills required for disease prevention. Once the patient has demonstrated that they have these skills, it then becomes their responsibility to practice them. There is a tendency for some practitioners to blame patients for having poor oral hygiene before the necessary skills have been mastered. It is extremely important for patients to understand that dentists or dental hygienists are there to facilitate the learning of plaque-removal skills. The practitioner’s role is to help patients learn.

As oral hygiene instructions involve the teaching of skills, the therapist must somehow determine if the patient has learned the necessary skills. Many therapists give oral hygiene instructions by demonstrating the use of plaque-removal devices, but do not ensure that their patients can perform the required skills. There are many different effective ways to teach plaque control. One approach involves three simple components: demonstrate basic oral hygiene procedures (e.g. brushing + interproximal care) in areas...
requiring improvement; ask the patient to clean their teeth the best they can before coming in for their next appointment; and, at the next visit, look for sites with and without plaque, to evaluate what skills the patient already has and which ones still need to be mastered. Most adult patients have some plaque-control skills that were learned long ago (i.e. usually in childhood). The patient’s time should not be wasted by showing them something they already can do; the focus should be on what they cannot. Indeed, many patients already have well-developed tooth-brushing skills, and the greatest challenge is to develop effective interproximal care.

**Scaling and root planing**

Subgingival scaling and root planing is the instrumentation applied to a root surface until it becomes clean, smooth and hard, as detected with a dental explorer. Most authorities agree that carefully performed scaling and root planing is one of the most indispensable and effective parts of periodontal therapy (20–22, 39, 42, 43, 53, 100, 118, 139, 314). Alone or in combination with other therapeutic procedures, scaling and root planing is universally employed in the treatment of every case of chronic periodontitis.

There are two clinical end points of scaling and root planing. The first is when the practitioner decides that a root surface is smooth when examined with a dental explorer. Smoothness is used as a clinical sign that the subgingival calculus has probably been completely removed. In other words, it is a surrogate for a clean root (i.e. there is no residual calculus). In fact, numerous studies have shown that after scaling and root planing there are often microscopic islands of residual calculus (34, 37, 86, 138, 227, 250, 271, 287, 288, 317). If this calculus is clinically important, there will be an unfavorable post-scaling and root planing response, in which there are persistent signs of inflammation (e.g. redness, swelling and bleeding on probing). If the residual microscopic flecks of calculus are unimportant, within weeks after the scaling and root planing has been completed there should be no signs of inflammation. Therefore, the second, and most important, clinical end point of scaling and root planing is the resolution of inflammation. Figure 1A shows a patient who had scaling and root planing performed by a novice clinician 4 weeks before the photograph was taken. There are residual signs of gingival inflammation (e.g. redness and swelling) around many of the teeth. Figure 1B shows the same area after reflection of a periodontal flap. Most teeth have large deposits of residual subgingival calculus that were missed during the scaling and root planing procedure. The novice clinician who initially treated this patient quickly learned that scaling and root planing is an extremely difficult and technically demanding procedure!

The completeness of calculus removal is influenced by the experience and skills of the operator (86) and the depth of the periodontal pocket to be instrumented. In general, the deeper the pocket, the more difficult the task. Most studies indicate that after scaling and root planing the greatest amount of residual subgingival calculus is found at sites with initial probing depths of ≥6 mm (34, 37, 86, 138, 226, 287, 288). One of the clinical take-home messages of these
studies is that scaling and root planing at sites with probing depths of $\geq 6$ mm is often beyond the skills of most practitioners. Scaling and root planing at deep sites is likely to leave clinically significant deposits of subgingival calculus and its associated disease-producing biofilms. There are, of course, a few exceptions. There are some gifted clinicians with the rare ability to perform satisfactory scaling and root planing at sites with probing depths much greater than 6 mm. However, most clinicians should consider referring patients who have multiple pockets of $\geq 6$ mm to a periodontist. It is never a good idea to tell patients that you are going to “perform a deep cleaning (i.e. scaling and root planing) at very deep sites to see what happens.” Indeed, in the hands of most practitioners, it is already known that scaling and root planing will not be effective at sites with probing depths $\geq 6$ mm.

It is sometimes easy to forget that subgingival calculus per se is not the principal cause of periodontal disease. Calculus is little more than the mineralized remnants of dead biofilm bacteria. Compared with the highly toxic living microbial communities (i.e. biofilms) that colonize teeth, sterilized calculus is only a low-grade irritant (10). Indeed, in the hands of most practitioners, it is already known that scaling and root planing will not be effective at sites with probing depths $\geq 6$ mm.

The evaluation visit is of major importance because it sets the stage for long-term therapeutic outcomes. This visit is usually scheduled 4–6 weeks after the
completion of scaling and root planing and delivery of oral hygiene instructions. If these interventions have been effective there should be little or no signs of residual gingival inflammation (e.g. redness, swelling or bleeding on probing) (132). Indeed, if the patient’s plaque control has been satisfactory in the past 4–6 weeks and the scaling and root planing was performed well, there should be minimal or no signs of inflammation at the evaluation visit (Fig. 4).

However, if there are some residual signs of inflammation, the practitioner must determine the cause. Is there a problem with the patient’s oral hygiene skills? Is the patient missing key areas whilst performing oral hygiene? Does the patient need some additional help in mastering the necessary oral hygiene skills? Alternatively, is the gingival inflammation associated with some subgingival calculus that was left behind during the scaling and root planing procedures? The important point is that if there is residual inflammation only 4–6 weeks after the delivery of oral hygiene instructions and scaling and root planing interventions, the treatment is beginning to show signs of failure. Patients who still have a considerable amount of post-treatment gingival inflammation are not yet ready for placement on a maintenance program.

It can be argued that at the evaluation visit there will always be some clinical signs of slight gingival inflammation, especially at interproximal sites where it can often be quite difficult to master plaque-removal skills (e.g. flossing and use of interdental aids). It must be remembered that it is the therapist’s responsibility to teach plaque-control skills that are sufficient to prevent the recurrence/development of periodontal disease and dental caries. Until this is achieved, the therapist’s role as a teacher is not yet complete. For most patients, mastering adequate plaque-control skills takes time. More time than is usually scheduled for the scaling and root planing visits (123). Therefore, it is often necessary to incorporate plaque-control teaching activities in other dental visits, such as those needed for restorative care.

The yes-or-no decision by a therapist regarding their patient’s readiness for a periodontal maintenance program depends on a careful evaluation of the responses to oral hygiene instructions + scaling and root planing, as well as a thoughtful analysis of risk factors for the recurrence of periodontal disease. The decision is particularly difficult because of the complex array of local (179) and systemic (65, 94, 295) risk factors that can affect the susceptibility to

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Fig. 2. Subgingival calculus (white arrow) with closely adapted pocket epithelium in a 68-year-old man who had chronic periodontitis at the time of his death. (A) The calculus is present some distance away from the more coronally positioned biofilm (16× magnification). (B) Tissues apical to the same deposit of calculus shown in (A) (16× magnification). (C) Higher magnification of the calculus–epithelium interface (80× magnification. a, artifact; E, pocket epithelium; ICT, inflamed connective tissue.)
periodontitis. In general, anything that interferes with or alters innate (142) or adaptive (75, 116) immune responses to a bacterial challenge are risk factors for periodontal disease. For example, cigarette smoking has adverse effects on the antibacterial actions of polymorphonuclear neutrophilic leukocytes (102, 212, 219, 292, 293), which explains, in part, its strong association with an increased risk of the progression of periodontitis (109, 130, 249). Also of concern are sites with post-scaling and root planing probing depths of $\geq 6$ mm that exhibit bleeding on probing because of their reported association with an increased risk of additional loss of clinical attachment (180, 181). Finally, the risk-assessment process must include analysis of any systemic risk factors, such as diabetes mellitus, that can increase susceptibility to periodontitis (57, 94, 153, 186, 224, 305). Patients should only be placed on a periodontal maintenance therapy program if their periodontal disease has been arrested. In other words, if the response to oral hygiene instructions + scaling and root planing has been favorable and the risk for dental caries and recurrence of periodontal disease is low.

A critical step at the evaluation visit is filling out a post-treatment chart that records a number of important periodontal findings, including: the amount of clinical attachment loss; full-mouth probing depths; and sites with bleeding on probing or other signs of inflammation. The overall purpose of this post-treatment periodontal chart is to serve as a baseline for comparison of measurements made during the maintenance program. Of particular importance is the clinical attachment loss measurement. Clinical attachment loss is measured using a calibrated periodontal probe and is the distance from the cemento-enamel junction to the base of the probeable crevice (Fig. 5). The clinical attachment loss is a clinical estimate of the amount of periodontal damage in millimeters (14). Although the clinical attachment loss measurements are checked at each periodontal maintenance therapy visit, it is usually a good idea to record them formally at least once per year. A visit-to-visit or year-to-year increase (e.g. $\geq 2$ mm change) in a clinical attachment loss measurement is the most reliable sign of a failing periodontal maintenance therapy program. If it is clear that the program of supportive care is not working, it is imperative that something else needs to be done.

### Choosing the maintenance/recall interval

The appropriate recall interval is not the same for all patients. In some individuals with a high risk of disease recurrence or progression, short recall intervals...
The recall interval should be adjusted to fit the patient’s needs. For over 100 years, clinicians have been recommending patient-specific recall intervals (see Quotation Box 2).

Most patients with a history of generalized severe chronic periodontitis that has been recently treated and stabilized are initially placed on a periodontal maintenance therapy program with a 3-month recall interval. The basis for this relatively short interval is the fact that people with a history of severe disease are, by nature, at high risk for recurrence. In addition, longitudinal clinical results from treated-and-main- tained populations (17–19, 45, 63, 93, 114, 118, 125, 129, 140, 159, 160, 174, 185), and data from random- ized controlled clinical trials (96, 110, 120, 121, 144, 162, 163, 220, 229–232, 258, 259), clearly show that supportive periodontal care at 3- to 4-month intervals works for most individuals (11, 54).

**Completing the evaluation visit**

At the end of the post-treatment evaluation visit it is important to ensure that all supragingival and subgingival biofilms have been removed from all teeth before dismissing the patient. The patient should leave the evaluation visit with a clean mouth. The reason for this intervention is simple – established microbial communities (i.e. biofilms) are required to produce disease (2, 74, 83, 166, 168, 170, 199, 291, 306). The goal is to create an environment in which oral bacteria must start over to form disease-produc- ing microbial communities. Therefore, everything that one observes at the first maintenance visit will be a reflection of how well the patient is doing with oral hygiene and how effective the scaling and root plan- ing has been in preventing the recurrence of disease. It makes absolutely no sense to start a patient on a periodontal maintenance therapy program whilst they still are heavily colonized with established disease-producing subgingival biofilms.

**Procedures performed during the periodontal maintenance therapy visit**

The overall concept behind maintenance visits is quite simple – to minimize the recurrence of disease through periodic preventive interventions. However, a well-organized maintenance visit is an art form that involves some critically important analyses and complex interventions that fit the individual needs of patients. Some of the routine tasks performed at maintenance visits include: review of medical/dental histories; complete oral examination; establishing whether the maintenance program is working; evaluation of oral hygiene; and full-mouth supragingival and subgingival debridement (i.e. biofilm removal). The first two items on this list are self-evident and will not be discussed further.

**How can one determine if the maintenance program is working?**

As noted above, before placing a patient on a mainte- nance program, a detailed periodontal chart should have been completed at the post-treatment evalua- tion visit. Measurements on this chart serve as a baseline for all future comparisons during maintenance care. Of particular importance are the site-by-site measurements of damage or clinical attachment loss in millimeters. If the maintenance program is working, there should be no significant increase in clinical
attachment loss from visit to visit. A clinical attachment loss change of ≥2 mm is usually considered to be clinically relevant because it is greater than the 1 mm variation in measurement associated with periodontal probe assessments of clinical attachment loss values (13). Indeed, changes in clinical attachment loss are the best way to determine if there has been recurrence and progression of periodontitis.

Quotation Box 2 Historical recommendations on treatment and maintenance (recall) intervals for patients with a history of periodontitis.

Miller (1890): I have ... generally found an after-treatment necessary at intervals of from four to six months...

Black (1915): ... a considerable percentage of our people should come more or less frequently – the interval to be adjusted to the individual – for the removal of these deposits...

Taylor (1930): inflammation is the cause and scaling and root planing the treatment; good oral hygiene by the patient is critically important. Recalls are recommended once/month until stable and then at 3-month intervals for those who originally had advanced disease

There is, I believe, just one thing that causes pyorrhea, and that is inflammation. If we can prevent this, we can prevent pyorrhea.

What we must do is to take instruments of proper size and shape and with them go to the very bottom of the pocket, curetting it until the surface of the root is smooth.

The home care of the mouth by the patient is of the greatest importance.

The patient should return for examination and prophylaxis at least once a month for three, four, or six months according to the severity of the case. When we are sure that there is no inflammation ... the patient should be asked to return for prophylaxis once every three months.

Tracy (1930): teaching patient how to perform oral hygiene is critical; recall intervals to prevent caries and periodontal disease may differ from patient to patient and should be arranged “according to their needs”.

Goldman (1949): ... the patient should be recalled at different intervals ... spacing of this procedure is dependent upon the oral hygiene practiced by the patient...
Full-mouth biofilm removal/disruption

An essential intervention during maintenance/recall visits is the mechanical removal or disruption of any established supragingival and subgingival microbial communities that might have formed since the last visit. The general goal of this intervention is to disrupt any organized biofilms. After the regrowth or re-formation of these biofilms, there is a delay before they regain their disease-producing ability. To be certain that the biofilms have been adequately removed/disrupted, it is necessary for therapists to use an instrumentation end point different from that used during scaling and root planing procedures. As discussed above, the first end point of scaling and root planing is when the practitioner decides that a root surface is smooth when examined using a dental explorer. However, patients who are on maintenance programs should already have smooth roots because detectable deposits of subgingival calculus should have been removed during the scaling and root planing sessions performed during the initial periodontal therapy. Although supragingival calculus can form quite rapidly after scaling and root planing if a patient’s plaque control is not perfect (29, 90, 319, 326), formation of subgingival deposits is a very slow process (254, 319). Indeed, the detection of black or brown hardened subgingival calculus at a maintenance visit probably means that the deposit had been missed at a previous scaling and root planing session (Fig. 1). Removal or disruption of subgingival biofilms at a maintenance visit is best performed with the careful use of curets or other appropriate hand instruments. Debridement is complete when all clinically detectable plaque/biofilm has been removed from all subgingival sites. The instrumentation end point is an empty curet (i.e. no plaque can be seen on the curet’s working surface as it exits from the gingival sulcus or pocket). If performed carefully, no local anesthesia is usually needed.

Root caries

Particular attention should be directed toward the detection of root caries because these lesions are a reported complication in patients undergoing periodontal maintenance (26, 45, 172, 189, 213, 218, 234–237). One of the potential reasons for this complication is that patients who have been treated for periodontitis often have gingival recession with root surfaces exposed to a supragingival cariogenic environment. In addition, some data suggest that there is an increase in the numbers of cariogenic bacteria in the oral microbiota after chronic periodontitis has been treated (69, 226, 313). However, it should be emphasized that tooth loss because of dental caries is very low in patients who practice a high standard of oral hygiene and comply with recommended maintenance intervals (19).

Poor compliance (i.e. attendance) with the recommended maintenance interval

It is widely acknowledged that inadequate oral hygiene during the maintenance phase of care and poor compliance with the recommended maintenance interval are significantly associated with unwanted results, such as the recurrence/progression of periodontitis (59, 67, 70, 114, 171, 205–209, 218), increased clinical attachment loss (58, 209, 218), deeper probing depths (58, 209), root caries (26, 122, 137, 216, 218, 237, 256) and tooth loss (57–59, 77, 81, 114, 140, 172, 193, 281, 311). Therefore, it is extremely important for therapists to convey clearly to their patients the potential negative outcomes associated with lack of compliance to maintenance intervals.

Long-term post-insertion care for dental implants

Peri-implant diseases can be divided into two general categories: peri-implant mucositis; and peri-implantitis. Peri-implant mucositis is characterized by clinical inflammation (e.g. bleeding on probing, purulent exudate, redness and swelling) limited to the soft tissue (i.e. the mucosa) surrounding the dental implant, without radiographic signs of bone loss. Peri-implantitis is inflammation of the peri-implant mucosa plus progressive loss of supporting peri-implant bone beyond the biological remodeling that follows implant loading (257, 269). Peri-implant diseases are common, with the reported prevalence of peri-implant mucositis ranging from 31% to 64.5% of subjects and 21.6% to 38% of implants (145, 176, 192, 246, 248). The prevalence of the more severe peri-implantitis ranges from 11.2% to 47.1% of subjects and 6.6% to 36.6% of implants (87, 145, 147, 176, 192, 246, 248, 255).

Risk factors and indicators for peri-implant diseases

The risk factors for peri-implant diseases are very similar to those associated with periodontal diseases (147, 152, 176, 221). For example, individuals with
poorly controlled diabetes are at increased risk of developing both periodontal and peri-implant diseases (47). Given this, it is not surprising that multiple clinical reports and systematic reviews have found that peri-implantitis is more frequently diagnosed in patients who have had, or currently have, periodontitis compared with those with healthy periodontal tissues (35, 38, 48, 49, 60, 64, 66, 68, 83, 111, 126, 134, 135, 143, 146, 147, 158, 176, 178, 211, 228, 238, 252, 253, 277, 279, 290, 327). However, patients with a history of successfully treated periodontitis who comply with a periodontal maintenance program are not necessarily at increased risk of developing peri-implantitis (143, 158, 190, 277, 327).

Poor oral hygiene is commonly listed as a major risk factor for peri-implant diseases (83, 127, 165, 265, 285, 327). The reverse is also true, in that good plaque control is one of the most important factors for the success and predictability of both periodontal (17, 51, 99, 169) and peri-implant (99, 126, 147) therapy. In some cases the prosthetic design of the implant suprastructure obstructs access for daily plaque control (126, 285). This problem can be minimized by constructing a suprastructure that makes it easy for the patient to perform oral hygiene.

Based on convincing data, it has been shown that cigarette smoking is an independent risk factor for the development and progression of chronic periodontitis (12, 56, 131, 149, 194, 203, 262, 266, 328). A similar story has emerged regarding smoking as a significant risk factor for the development of peri-implantitis and implant loss (5, 24, 35, 49, 52, 68, 72, 91, 108, 111, 113, 143, 165, 200, 204, 296, 315, 327). The precise reasons why smoking increases the risk of implant failure are not known. However, smoking has profound negative effects on innate and adaptive immune responses (12, 76, 107, 128, 131, 141, 292, 293). Impairment of these host-defense responses to a microbial challenge around an implant can easily explain why smoking disrupts the host-microbe homeostasis required for long-term implant retention. In addition, data indicate that smoking interferes with the healing of oral wounds (124, 131, 150, 282). Overall, smoking clearly increases the risk for peri-implantitis. However, this does not mean that dental implants should never be placed in smokers. Some follow-up studies have found that smoking is not associated with implant failure (217, 318).

Another factor increasingly implicated as an important contributor to the etiology of peri-implantitis is residual cement left behind at submucosal sites after cementation of implant crowns (4, 148, 164, 316, 320). Much like an overhanging restoration (154), excess cement probably provides an environment that favors the colonization and proliferation of bacteria. It has also been suggested that cement and implant-associated materials might elicit a foreign-body reaction that contributes to implant failure (9, 322). Removal of this excess cement is often made difficult by the implant position and prosthetic design of a crown that limits access to the submucosal sites adjacent to the implant (164). In addition, the majority of cements used for implant-crown placement are radiolucent, thereby limiting their detection during radiographic examinations (316). Construction of over-contoured and bulky crowns that restrict submucosal access around implants should be avoided. Bulky crowns make it difficult to perform daily plaque control and interfere with the removal of supramucosal and submucosal microbial deposits during maintenance visits.

By virtue of being placed in the microbe-laden oral environment, all dental implants are at risk of developing peri-implant diseases. It is clear that biofilms form rapidly on both smooth and rough implant surfaces (46, 184, 280, 294, 298). It is critically important that a patient-specific program of professional care be established to prevent the development of microbe-associated peri-implant diseases. The program should include: individual oral hygiene instructions; control of relevant risk factors; and provision of professional preventive interventions, including maintenance care (309). The primary goal of a program of supportive implant therapy is to prevent the development of peri-implantitis. This is especially important because once peri-implantitis occurs it is extremely difficult to treat. Indeed, there is no reliable evidence on the best way to treat this condition (79, 80, 243–245). It has generally been assumed that the best way to keep peri-implant tissues healthy is to place affected patients on a well-designed supportive implant therapy program that stresses excellent oral hygiene and periodic recall visits for professional removal of biofilm deposits from implant surfaces (6–8, 15, 60, 117, 222, 268, 309, 323, 327). This approach has also been advocated for reversing the course of peri-implant mucositis (8, 30, 73, 99, 112, 182, 247, 307). Several protocols have been proposed for supportive implant therapy programs (8, 55, 155, 157, 308) but there is no consensus on what specific interventions are required for the best results (119). However, data from multiple reports show that patients on supportive implant therapy programs have fewer post-insertion complications than do individuals who do not receive supportive care (6, 7, 15, 55, 59, 60, 88, 117, 225, 251–253, 267, 268, 286, 327).
Examination of dental implants during supportive implant therapy

The precise interventions provided during supportive implant therapy visits will be determined by the findings obtained following thorough examination of the peri-implant tissues and a careful assessment of the risk factors for peri-implantitis. A complete examination of the status of dental implants includes the same general steps performed during a routine examination of the natural dentition. The peri-implant tissues must be examined for signs of inflammation, such as redness, swelling, bleeding on probing and suppuration. These signs are present when there is some peri-implant disease (i.e. peri-implant mucositis or peri-implantitis) (126, 155). The presence of suppuration is of particular concern (329). The patient’s oral hygiene is also evaluated to determine if the inflammation is plaque associated.

Peri-implant probing depths are recorded at the same six sites that are routinely measured around natural teeth (i.e. mesiobuccal, buccal, distobuccal, mesiolingual, lingual and distolingual) (14, 105). The current consensus is that the use of conventional periodontal probes around implants, “…damages neither the mucosal attachment nor the implant” (161). Several studies have clearly shown that probing submucosal sites around implants with gentle insertion pressures provides useful diagnostic information regarding the clinical status of the implants (1, 32, 95, 156, 195, 278). For conventionally placed dental implants and under healthy situations, probing depths usually vary between 2 and 4 mm (3, 36, 78, 196). However, it is possible at esthetic sites, where the implants have been intentionally placed deeper, or in cases where the mucosa is thick, that the initial probing depth might be greater. Increases compared with the baseline probing-depth values should be viewed as a possible sign of peri-implant disease. Clinicians should bear in mind that, unlike the natural dentition, probing around implants might be challenging. Accuracy is often affected by factors such as bulky contours of the implant and the presence of a prosthesis. In situations like this it is recommended that at least one surface be identified, “…where proper probing can be performed” (161).

The functional properties of implants are determined by checking their occlusion and for the presence or absence of mobility. The presence of mobility is, of course, a reliable sign of implant failure and loss of osseointegration (161). Mobility can be assessed either manually or by using instruments designed to evaluate implant stability (82, 89, 151, 210, 260, 283, 324). It is critically important to be able to decipher if the mobility is related to the implant body or whether it is associated with loosening of the restorative suprastructure.

In conjunction with the clinical examination, radiographs provide useful information regarding the status of dental implants. According to a consensus statement of the 6th European Workshop on Periodontology, “Baseline radiographs should be taken approximately at the time of placement of the suprastructure to establish the level of supporting bone” (161). At subsequent examinations (e.g. during maintenance visits), additional radiographs should be taken if there is a clinical suspicion that the implant may be losing some of its osseous support. There are no widely accepted protocols regarding the frequency of implant radiographic examination. However, if there are clinical signs of peri-implantitis, such as increased probing depth with bleeding on probing, radiographs should be taken to confirm the diagnosis (161).

Biofilm removal from implants during supportive implant therapy

If the peri-implant tissues are clinically healthy there should be no signs of clinical inflammation. In addition, probing depths and clinical attachment levels around the implant should not show any signs of progression compared with baseline measurements taken after implant loading. In such cases it can be assumed that there is a homeostasis between the peri-implant tissues and the microbial communities that have colonized the device. The diagnosis for this set of findings would be peri-implant health and the appropriate intervention would be coronal polishing with a rubber cup and low-abrasive paste (177).

If the tissues supporting the implant are stable (i.e. no increase in probing depths and no change in radiographically assessed bone levels) but there are clinical signs of inflammation, the appropriate diagnosis would be peri-implant mucositis. In this scenario there has been a shift from the health-associated host–microbe homeostasis to a balance that favors proliferation and persistence of inflammation-triggering microbial communities. This should be of concern because there is evidence that some cases of peri-implant mucositis can progress to peri-implantitis (40, 41, 126, 267, 268). Sites with peri-implant mucositis should be treated with the goal of returning the soft tissues surrounding the implant to a state of health. Unfortunately, there is no reliable
evidence to help clinicians select the best interventions to achieve this goal (101).

Several proof-of-principle studies on small populations have been conducted on the treatment of peri-implant mucositis (30, 50, 73, 84, 99, 104, 112, 182, 223, 240, 247, 274, 297, 307). The general approach has been to emphasize improvement in daily oral hygiene, mechanical debridement of submucosal pockets adjacent to the implant and establishment of a supportive implant-therapy program of periodic professional care. In most, but not all, instances, this group of interventions is able to stop the peri-implant mucositis and return the surrounding tissues to a clinically healthy state (84, 112, 240). The main challenge in treating peri-implant mucositis is selection of the best method for removal or disruption of peri-implant biofilms at submucosal sites.

**Instruments to use**

Instruments for the removal of submucosal microbial deposits from implant surfaces should be effective without causing significant damage to the implant. Use of instruments that are harder than the titanium implants increase the likelihood of leaving deep scratches in the implant that can serve as reservoirs for inflammation-triggering microbial communities. Conventional steel curets and scalers are harder than titanium and are usually not considered as being a viable option. Therefore, instruments made of materials softer than titanium have been used. Several in vitro studies have been conducted to investigate the effects of different types of instruments on the roughness of implant surfaces (16, 23, 30, 33, 71, 92, 115, 173, 175, 177, 187, 188, 214, 215, 233, 261, 263, 264, 270, 275, 276, 280, 312, 325).

Among the instruments tested were curets made of various plastics (4, 16, 33, 61, 71, 103, 115, 184, 187, 188, 214, 233, 270, 275, 276, 280, 294, 325) or carbon-fiber reinforced resins (112, 239–241, 275). Based on in vitro data, in the 1990s it was concluded that plastic curets are the “instruments of choice” for debridement of titanium implant surfaces (103, 294). However, this conclusion is only true if the main goal is to preserve the original physical characteristics of the implant surface. Plastic curets often break (84) and major questions have been raised about their ability to remove tenacious microbial deposits effectively from implant surfaces (223, 275). Concern has also been expressed about plastic fragments left behind on implants after instrumentation (175). Finally, plastic instruments are often unable to remove residual submucosal cement completely after placement of the crown on the implant (4). Overall, dissatisfaction with the clinical utility of plastic curets for submucosal instrumentation around implants has led to the testing of curets coated with soft metals, such as a gold–platinum alloy (33, 61) or titanium (30, 104, 187, 188).

In addition to manual curets that are specifically designed for instrumentation of implant surfaces, other methods to clean implants during maintenance visits have been designed and initially tested. In cases in which peri-implant mucositis has been diagnosed, modified piezoelectric or ultrasonic scaler tips for disruption and removal of submucosal microbial deposits on implants have been developed (30, 136, 286). To minimize damage to the implant surface, ultrasonic scalers with soft (non-metal) (23, 30, 136, 175, 187, 261, 270) or copper alloy (23) tips have been used with some success. Although there is currently no universal consensus on the best way to prevent and treat peri-implant mucositis, it is not acceptable to do nothing and wait until a full-blown case of peri-implantitis has developed.

The focus of this review on supportive implant therapy has been on the recognition, prevention and treatment of peri-implant mucositis. No discussion has been attempted on the treatment of peri-implantitis because this complicated condition often requires surgical exposure of the implant. It is not a minimally invasive procedure. Nevertheless, an important step in the management of peri-implantitis is thorough removal of the microbial deposits that have formed on the irregular surface of the implant. Once the implant has been surgically exposed it must be cleaned. Suitable instruments include manual titanium-coated curets or a piezoelectric unit equipped with a soft scaler tip. Other interventions that have their advocates include air polishing with a mildly abrasive (glycine) powder (264, 275, 303) and debride ment with erbium-doped yttrium aluminium garnet (Er:YAG) lasers (276, 280).

**Concluding remarks**

Periodontal maintenance therapy and supportive implant therapy are necessary for long-term success. Indeed, the treatment of moderate-to-severe cases of chronic periodontitis without a well-planned and executed maintenance program is likely to fail. In the past 50 years, a strong body of evidence has been obtained to support this conclusion. Similarly, evidence is emerging that placement of dental implants without a structured maintenance program increases the risk of implant loss. Implants should not be
placed unless the clinician is prepared to make sure that a suitable program of supportive implant therapy is readily available.

References


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