Surgical and non-surgical treatment of chronic periodontal disease

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Purpose: The aim of this paper is to provide guidelines for treatment planning of chronic periodontal disease (CPD) based on an evidence-based approach to the available research data.

Materials and Methods: Critical appraisal of longitudinal trials developed for the comparison of different modalities of periodontal treatment is included.

Results: Treatment of CPD can be broadly classified into either surgical or non-surgical approaches. Non-surgical therapy includes plaque control, supra- and subgingival scaling, root planing (SRP), and the adjunctive use of chemotherapeutic agents. Surgical therapy can be divided into either resective or regenerative procedures. The majority of articles reviewed agree that when adequate access for root debridement is achieved, non-surgical treatment of CPD seems to be as effective as surgical treatment in the long-term maintenance of clinical attachment levels (CAL). SRP is limited by the presence of furcation involvements, deep pocket depths, and root anatomy.

Conclusion: Decision-making in periodontal therapy requires a thorough understanding of the long-term outcomes of all available treatment modalities. Studies have consistently shown that SRP can provide similar improvements of clinical attachment levels when compared to surgical treatment. However, several factors need to be considered when deciding on which treatment approach to select for the treatment of chronic periodontal disease. **(Int Chin J Dent 2002; 2: 15-32.)**

INTRODUCTION

According to the official guidelines of the American Academy of Periodontology, the goals of periodontal therapy are to preserve the natural dentition; to maintain and improve periodontal health, comfort, esthetics, and function; and to provide replacements (i.e., dental implants) where indicated.[1] Several treatment modalities to achieve these goals are available in periodontics, and they can be broadly classified into either surgical or non-surgical approaches. Non-surgical therapy includes plaque control, supra- and subgingival scaling, root planing, and the adjunctive use of chemotherapeutic agents. Surgical therapy can be divided into either resective or regenerative procedures. The aim of this paper is to compare surgical and mechanical non-surgical periodontal therapy in terms of efficacy, clinical applicability, and ability to meet the stated goals of periodontal therapy. A review of longitudinal trials comparing the two treatment approaches is included, along with a discussion of the advantages and limitations of each.

HISTORICAL BACKGROUND

Applying the proper therapy for any disease begins with the recognition and thorough understanding of the etiology and pathogenesis of the disease process. Treatment modalities have, therefore, always been directed at the etiologic factors recognized at the time of treatment. This section is included to provide an understanding of the decision-making process involved in selecting periodontal treatment modalities over time.

The prevailing concept at the beginning of this century was that periodontal disease involved necrosis of the bone, and, consequently, treatment was aimed at removing the necrotic bone.[2] Flap procedures and/or gingivectomies were performed to gain access to remove the infected, necrotic bone. Work by Kronfeld et al. aided in dismissing the belief of bone necrosis.[3] Gingivectomy became the predominant form of therapy because the etiology was shown to be an inflammatory process of the soft tissues that led to alveolar bone destruction. The concept of "pocket elimination" was therefore introduced and widely practiced, especially after Gottlieb et al. had already established the pocket as a "chief prerequisite for the existence of pyorrhea".[4]

Bunting was among the first to recognize the preventable nature of periodontal disease and the role of cleaning the roots in prevention.[5] However, it wasn't until the classical studies by Waerhaug and co-workers were published that the role of plaque and calculus in the pathogenesis of periodontal disease was clearly recognized.[6-8] Several studies in the 1960s and 1970s on experimental gingivitis, microbial composition of plaque, and the effects of treatment and oral hygiene (OH) on periodontal disease contributed to the evolution of periodontal therapies aimed at preventing and arresting periodontal diseases. Although the identification of the role of systemic host factors and the development of guided tissue and bone regeneration procedures have led to a more complex array of treatment modalities, the basic therapeutic armamentarium can still be generally classified into surgical and non-surgical approaches. In order to identify the best treatment approaches several longitudinal clinical trials were developed.

LONGITUDINAL STUDIES

According to Ramfjord, longitudinal trials to evaluate response to periodontal therapy are needed for several reasons. Due to the chronic nature of periodontal disease and the slow progression of attachment loss (estimated to be 0.2 mm/year),[9] and the limitations of the traditional periodontal probe, prolonged observation periods with as many patients as possible are needed to allow detection of any measurable changes. Several longitudinal studies of varying duration have been conducted to compare periodontal treatment modalities. The studies are commonly grouped by geographical location for identification.[10]

A comparison of surgical and non-surgical therapy was first reported by Ramjford and coworkers (Michigan studies).[10-16] Later reports include studies by Philstrom et al. (Minnesota studies),[17-19] Lindhe and coworkers (Swedish studies),[20-27] Isidor and Karring (Denmark studies),[28,29] and Kaldahl and coworkers (Nebraska studies).[30-32] Badersten/Egelberg and coworkers (Lund/Loma Linda studies)[33-48] examined the

effects of non-surgical therapy on clinical parameters. Some studies used single-rooted teeth, and all studies were performed in a university setting except for the Arizona (Tucson-Michigan-Houston) studies,[49-51] which were conducted in a private practice setting. The longitudinal studies used combinations of traditional clinical parameters such as clinical attachment level (CAL), probing depth (PD), bleeding upon probing (BOP), gingival index (GI), plaque index (PI), and others, to compare the response achieved after different types of therapy. Several investigators compared different surgical approaches such as Modified Widman's Flap (MWF), Apically Positioned Flap (APF) with and without osseous surgery (OS), pocket elimination surgery (PE), and the Modified Kirkland Flap (KF).

AMERICAN STUDIES (Table 1)

Michigan Studies: The Michigan group leaded by Ramfjord developed the first longitudinal studies that prospectively compared different treatment modalities over an extended period of time.[11,13] Their work began to focus attention on the long-term rather than the short-term results of periodontal treatment. The first two studies evaluated response to subgingival curettage (CR) versus pocket elimination surgery (PE),[11] and CR, PE, and MWF.[13] Results in the Knowles et al. report indicated that PD and CAL can be improved and maintained long-term after all three methods in moderately deep (4-6) and deep (7-12) mm pockets. The authors also showed a positive relationship between initial PD and the magnitude of PD reduction and changes in CAL. However, the therapeutic impact of initial non-surgical therapy (SRP) on surgical results was not evaluated, since baseline measurements were obtained prior to initial therapy. Still, these studies were the first to demonstrate that equivalent or even superior results can be achieved with more conservative procedures (CR) as opposed to resective procedures (PE). Hill et al. and Ramfjord et al. included 90 patients followed up for five years.[10,14] Measurements were made both prior to and one month following completion of initial therapy. A split mouth design was used to reduce biological variability. The two-year data of 90 patients with initial attachment loss on ≥ 20 teeth was published in 1981, and the five-year data in 1987. Following baseline measurements, initial therapy consisting of oral hygiene instructions (OHI) and SRP, performed by a dental hygienist. Quadrants were randomly assigned to receive SRP, CR, MWF, or PE. Measurements were taken one month after hygiene phase completion (HPC), and annually thereafter. Patients were recalled weekly for the first four weeks after surgery, and at a three-month interval for the remainder of the study. Sites were divided into normal depth (1-3 mm), moderate periodontitis (4-6 mm), and advanced periodontitis (≥ 7 mm) for statistical analysis. The two-year results demonstrated that PD in all groups decreased after HPC. Comparison of the four treatment modalities indicated that 1) minimal PD reduction and CAL loss resulted in the 1-3 mm group following all treatment methods; 2) marked reduction in PD for 4-6 mm pockets resulted following MWF and PE, but they led to greater CAL loss than SRP; 3) PE led to the greatest reduction in PD for ≥ 7 mm pockets, but no significant differences in CAL gain were found between the four methods.[14] The five-year data comprised 72 patients who had completed the study. Their results indicated that normal pockets (1-3 mm) lost attachment following all procedures. PD in moderate pockets (4-6 mm) was decreased more following PE>

MWF > SRP > CR.

Table 1. American studies.

LOCATION	AUTHOR	COMPARISION	YEARS	RESULTS
MICHIGAN	Ramfjord et al. (1968)	CR, PE	2	**CAL:** Similar results for CR and PE
	Knowles et al. (1979)	CR, PE, MWF	8	**PD and CAL:** Improved for all 4-6 and 7-12mm pockets
	Hill et al. (1981)	CR, PE, MWF, SRP	2	**1-3mm:** Minimal PD reduction and CAL loss. No ≠ b/w groups **4-6mm:** More PD reduction PE> MWF, but more CAL loss than SRP **≥ 7 mm:** More PD reduction for PE, but no sig. ≠ in CAL gain b/w groups
	Ramfjord et al. (1982)	Effects of OH after therapy	8	**Higher OH**: More PD reduction and higher CAL gain
	Morrison et al. (1982)	Effects of GV after therapy	8	**GV:** No correlation with PD and CAL change
	Ramfjord et al. (1987)	CR, PE, MWF, SRP	5	**CAL: All groups lost** **1-3mm:** PE=MWF=SRP=CR **4-6mm:** PE>MWF>SRP>CR **≥7mm:** PE>MWF>SRP>CR **PD reduction** **1-3mm:** No changes **4-6mm:** Sig. reduction. No ≠ b/w groups **≥7mm:**PE>MWF>SRP>CR. No sig. ≠s
MINNESOTA	Pihlstrom et al. (1981)	SRP, SRP + MWF	4	**MWF:** Increase PD reduction and CAL gain for deeper pockets
	Pihlstrom et al. (1983)	SRP, SRP+ MWF	6 1/2	**1-3 mm:** MWF led to more CAL loss **4-6 mm:** Similar PD reduction. SRP caused less CAL loss **≥ 7 mm:** SRP had more PD recurrence vs. MWF
	Pihlstrom et al. (1984)	SRP, MWF Molar, Non-molar	6 1/2	**4 to 6mm:** less PD reduction and less CAL gain on molars vs. non-molars **≥7mm:** No ≠ b/w M and NM teeth following SRP alone
NEBRASKA	Kaldahl et al. (1988)	CS, SRP, MWF, APF+OS	2	**PD reduction:** APF>MWF>SRP>CS
	Kaldahl et al. (1996-I)	CS, SRP, MWF, APF+OS	7	**APF+OS:** Sustained more PD reduction on > 5 mm sites
	Kaldahl et al. (1996-II)	CS, SRP, MWF, APF+OS	7	**CS:** Higher incidence of breakdown **Breakdown/year:** SRP=MWF≥APF+OS in 1-6mm sites
LOMA LINDA	Badersten et al. (1981)	SRP: HI vs. USI	2	Comparable results obtained by both methods
	Cerceck et al. (1983)	OHI, SRP	2	**OHI:** Minimal effect; SRP: **Greater PD reduction and CAL gain**
	Badersten et al. (1984-II)	OHI, SRP; Severe Periodontitis	2	**Deep residual PD:** Higher incidence of BOP
	Badersten et al. (1984-III)	SRP; Single, repeated	2	No additional benefits of repeated SRP
	Badersten et al, 1985-IV	SRP; Operator variability	2	Operator variability between clinicians is minimal
	Badersten et al. (1985-V)	SRP; Recurrence of CAL loss	2	73% of the non-responding sites showed a linear pattern of CAL loss
	Badersten et al. (1985-VI)	SRP; Localizing CAL loss	2	**Initial shallow PD:** More CAL loss
	Badersten et al. (1987)	Effects of SRP	4	**Maintenance of CAL:** No ≠ b/w shallow and deep PD
	Nordland et al. (1987)	SRP ; M(molar), NM(non-molar), M w/ FI	2	**≥4.0mm:** M w/ FI responded less favorably to therapy **≥7.0mm:** M w/ FI showed higher recurrence of CAL loss
	Loss et al. (1989)	SRP; M, NM, M w/ FI	2	The greater the FI, the less response to SRP
TUCSON MICHIGAN HOUSTON	Becker et al. (1988)	SRP, MWF, APF+OS	1	**PD reduction:** APF+OS=MWF>SRP **CAL gain:** All treatments produced similar CAL gains
	Becker et al.(1990)	SRP, MWF, APF+OS	5	**PD reduction:** Significant and similar in 4-6 and ≥ 7 mm
	Kerry et al. (1990)	SRP, MWF, APF+OS	5	**1-3 mm:** Significant CAL loss; **4-6 and ≥ 7 mm:** Insignificant CAL gains

CR: Curettage; PE: Pocket Elimination Surgery; MWF: Modified Widman's Flap; SRP: Scaling and Root Planing; OH: Oral Hygiene; OHI: Oral Hygiene Instruction; GV: Gingivitis; CS: Coronal scaling; APF: Apically Positioned Flap; OS: Osseous Surgery; PD: Probing Depth; CAL: Clinical Attachment Level; BOP: Bleeding On Probing.

However, clinical attachment loss followed the same order. In deep pockets (≥ 7 mm), the differences between treatments in PD reduction observed after one year disappeared after five years. All treatment methods led to significant PD reductions from baseline levels, but no significant differences between the treatments were found. Also, after five years, only SRP and CR showed statistically significant gains of CAL compared to baseline values. No added benefit from CR was found beyond that of SRP.[10,14] Of interest was the observation that 16 out of 17 lost teeth had furcation involvement (FI) initially. It was also noted that more teeth receiving SRP needed re-treatment than the other procedures, but no difference in results was found after re-treatment was performed. The authors concluded that SRP was the treatment of choice for PD < 6 mm, provided that proper access to the root surface could be obtained. For PD of ≥ 7 mm, the results were similar for all four examined treatment modalities.[10]

The effects of personal plaque control and gingivitis on treatment were also reported. The 8-year results of 78 patients who had undergone non-surgical periodontal therapy and were on 3-month supportive periodontal therapy (SPT) interval demonstrated that variations in PD and CAL were related to individuals with plaque scores above and below the median. The data were analyzed by comparing the 25% of the sampling having the lowest plaque scores with the 25% having the highest scores over 7 years of SPT. It was found that personal oral hygiene (OH) as expressed in plaque scores was not critical for the maintenance of post-treatment PD and CAL in patients following a 3-month SPT interval. The initial post-treatment reductions in PD and variations of CAL were more favorable in patients with good than with poor OH, but these differences were not significant after 3 to 4 years of SPT. No consistent relationships were found between the degree of gingivitis and variations in the clinical parameters of PD or CAL. The tendency was for PD ≥ 7mm to show more initial PD reduction and CAL gains in patients with lower than median gingivitis scores than in patients with higher than median scores. The conclusion was that the severity of mild recurrent gingivitis during 3-month SPT interval has little if anything to do with the maintenance of PD reductions and CAL gains after periodontal treatment (Table 1).[12,15]

Minnesota Studies: Pihlstrom et al. published the results of a study comparing SRP and SRP followed by MWF using a split mouth design, in 17 patients with moderate to advanced periodontal disease.[17,52] Ten patients were available for examination at the conclusion of the study. Their results showed that surgery led to CAL loss in 1-3 mm sites, and that both methods were equally effective in PD reduction in 4-6 mm sites, with SRP causing less CAL loss. In ≥ 7 mm pockets, MWF resulted in sustained PD reduction for 6.5 years, while the PD reduction in the SRP group was only sustained for 3 years. However, both methods resulted in equally effective sustained gains of CAL.[17] A follow-up article interpreting the results of the previous studies was published, and compared molar and non-molar teeth. The results demonstrated that for 4 to 6mm pockets, greater PD and more apical CAL remained on molars than non-molars treated by either method of therapy. For PD ≥ 7mm there was no difference between PD reduction on molar and non-molar teeth following SRP alone. However, there was less overall PD on non-molars than molars following MWF, indicating a greater effect of PD reduction on non-molar than molar teeth with MWF. No difference between tooth types was found for CAL in pockets initially ≥ 7mm with either treatment method.

Both treatment methods resulted in at least maintenance of pretreatment CAL adjacent to molar and non-molar teeth.[18]

Nebraska Studies: Kaldahl et al. compared coronal scaling (CS), SRP, MWF, and APF with osseous surgery (OS) in a split mouth design study of multi-rooted teeth in 82 patients.[30-32] The two-year results showed that the APF with OS group had the greatest PD reduction, followed by MWF, SRP, and CS. Twenty percent of the CS teeth needed re-treatment, and this treatment modality was eventually dropped from the study after two years.[30] A subsequent article reported the seven-year results.[31] Patients were maintained on a 3-month SPT interval. The differences between treatment methods in PD reduction disappeared after five years, except for a sustained greater reduction of PD following APF with OS in > 5 mm sites. However, similar gains of CAL were seen in ≥ 7 mm sites with all methods. In the 1 to 4 mm group, APF with OS resulted in CAL loss, while SRP resulted in CAL gains. The study concluded that both surgical and non-surgical therapy led to improvement of clinical parameters that was sustained over the seven-year follow-up period.[31] When the incidence of sites breaking down was analyzed (≥ 3mm of CAL from baseline), sites treated by CS alone had a higher incidence of breakdown than other therapies through the first year of SPT. The breakdown incidences/year for SRP and MWF sites were similar and greater than those for APF with OS in 1 to 4mm and 5 to 6 mm pockets. However, since questionable teeth were extracted during surgery in the APF with OS group only, the incidence of breakdown sites in that group may have been underestimated. Breakdown incidences were greater with increasing PD severities regardless of when they were categorized. There was no further loss of CAL one-year after retreatment in 88% of sites. Patients with higher breakdown incidences tended to be smokers at the initial exam.[32]

Loma Linda Studies: A series of studies evaluating the response to non-surgical therapy originated in Lund (Sweden) and Loma Linda universities. The study by Cercek et al. is credited for evaluating the separate effects of OH and SRP after 2 years of non-surgical therapy. The study demonstrated that minimal effect was derived from patient's performed OH, whether supra- or subgingival, while the bulk of the effect was derived from SRP.[34]

Badersten et al. published a series of articles about the effects of non-surgical therapy. Initially, the 24-month results of a study comparing hand to ultrasonic instrumentation in patients with severe periodontitis (PD up to 12mm) were reported. Plaque control and supra- and subgingival debridement using hand and ultrasonic instruments in a split mouth design approach were used to treat single-rooted teeth. Comparable results were obtained by both methods. The results also illustrated that there is no certain magnitude of initial PD where non-surgical therapy is no longer effective. It was also shown that shallower sites were at risk of losing attachment, while the deep sites were more likely to gain attachment. Deep residual probing depth sites were more likely to bleed on probing.[36] The effects of single versus repeated instrumentation in non-surgical therapy were also compared. Single-rooted teeth of 13 patients with severe periodontitis were treated with ultrasonic instrumentation in a split mouth design in which one side received a single episode of instrumentation, while the other side received additional instrumentation at 3 and 6 months. The results showed no significant differences in clinical parameters between groups,

indicating that single-rooted teeth may be successfully treated by plaque control and a single episode of SRP. The results also suggested that recurrence of disease due to subgingival recolonization during the healing phase may not be a major clinical problem in dealing with single-rooted teeth.[35]

The effects of operator variability on the outcomes of SRP were evaluated when a periodontist and five dental hygienists were assigned to perform SRP and the outcomes were compared. The results indicated that operator variability between highly skilled clinicians is minimal.[40] The evaluation of the patterns of CAL loss in non-responding sites following SRP identified seven different patterns. A linear pattern of gradual loss of CAL was found for 73% of the non-responding sites. Of the less frequent patterns, 3 approximated a linear course and 3 were non-linear. Seventeen percent of the sites showed an early loss followed by a stabilization of attachment levels. Shallower sites showed a pattern of early loss followed by stabilization while deeper sites showed a gradual loss.[39] The finding that the majority of sites with CAL loss were present amongst initially shallow or moderately deep sites may indicate that attachment loss was due to trauma associated with SRP rather than loss as a result of a continuing, inflammatory disease process.[38] The results after 4 years of non-surgical therapy comprised a total of 2,214 sites in 46 chronic periodontitis patients, and showed little change during the 24-48 month interval in mean scores for BOP, PD, and CAL for all 3 groups of sites (PD$\leq$ 3.5mm, 4.0-6.5mm, and $\geq$ 7.0mm). Individual sites with CAL loss during the 24-48 month interval generally differed in location from those identified as having CAL loss during the preceding 0-24 month period. The loss of attachment during the 24-48 month period often seemed to be reversal of a prior gain in CAL during the 0-24 month interval. The conclusion was that the study failed to demonstrate that sites with deeper PD are more difficult to maintain than shallower sites.[53]

A common criticism of Badersten's reports is the exclusion of multi-rooted teeth. The applicability of such findings to molar teeth was therefore investigated in subsequent studies.[43,45] Nordland et al. (1987) evaluated the effect of plaque control and SRP in molar teeth. A total of 2,472 sites in 19 adult periodontitis patients were divided into non-molar (NM) surfaces, molar (M) flat surfaces, and molars with furcation involvement (MFI) and monitored every third month for 24 months. The results demonstrated that for sites with initial PD of $\geq$ 4.0mm, MFI sites responded less favorably to therapy as compared to M flat surfaces or NM sites. Among sites initially $\geq$ 7.0mm, 21% of MFI sites were identified as showing CAL loss as compared to 7% of the M flat surface sites and 11% of the NM sites.[43] Loos et al. analyzed the clinical effects of SRP in M and NM teeth. Twelve patients received one session of full-mouth SRP and were then monitored every 3 months for 24 months. The mean results indicated that initially moderately deep and deep MFI sites responded less favorably to therapy compared to NM sites and M flat-surface sites of similar PD. Initial improvements in PD measurements for moderately deep and deep MFI sites were limited and also tended to revert during the observation interval. Identification of individual sites with CAL loss disclosed that 25% of MFI sites lost CAL as compared to 7% for NM sites and 10% for M flat surface sites.[45]

Tucson-Michigan-Houston Studies: One of the most commonly cited concerns with longitudinal studies is their applicability to private practice situations. Ramfjord stated, "The results of clinical trials

will only indicate probable outcomes of various treatments when performed under the standardized conditions of the trial, and with personnel with similar training".[54] Becker et al. attempted to provide a more relevant clinical trial using a private practice setting. Sixteen patients with ≥ 2 sites having ≥ 6 mm of CAL loss in the posterior dentition were included in the study.[49] A split mouth design was used to compare the effects of SRP, MWF, and APF with OS performed by highly skilled periodontists in each treatment modality. The patients were maintained using the office's standard recall system (3-month interval). After one year, surgery resulted in greater PD reduction in the 4 to 6 mm and ≥ 7 mm groups than SRP. Surgery also resulted in significantly greater CAL loss in the 1 to 3 mm group, while all procedures led to CAL gain in the ≥ 4 mm groups. The results suggested that both surgical procedures were equally effective in reducing PD, while SRP was less effective in PD reduction. All three methods produced similar gains of CAL.[49] The five-year results were reported in two abstracts.[50,51] At the five-year evaluation, plaque and gingival indices were significantly reduced for all groups. All three methods produced significant PD reductions in the 4 to 6 and ≥ 7 mm groups, with no significant differences between methods. For CAL and gingival recession, 1 to 3 mm pockets had significant loss of CAL, and 4 to 6 and ≥ 7 mm pockets showed insignificant gains of CAL. All procedures produced significant gingival recession, with no significant differences found between methods.[50,51] The Tucson-Michigan-Houston studies reported results that were essentially the same as those reported by university studies, lending support to their validity and applicability to the private practice setting.

EUROPEAN STUDIES (Table 2)

Swedish Studies: Initially, the efficacy of different surgical approaches (MWF, APF with or without OS, and gingivectomy) were compared.[23,55] Comparison between surgical and non-surgical periodontal treatment was reported in the five-year results of a study comparing SRP alone and SRP followed by MWF [21, 24]. Fifteen patients were randomly assigned to receive one therapy in a split mouth design. Recall interval was every 2 weeks for the first 6 months, every 3 months for the next 18 months, and every 4-6 months thereafter. After 24 months, recall maintenance was limited to OHI and CS only. CAL and PD changes were reported as gain or loss of 2 mm or no change (± 1 mm). The two-year results included 15 patients, and the five-year data evaluated 11 patients who completed the study. After two years, surgery resulted in more PD reduction and CAL gain than SRP alone.[21] However, the five-year results showed no difference in PD reduction or CAL gain between the two groups.[24] The study related the importance of the patient's self-performed OH level to PD reduction and CAL gain during the healing and maintenance phases of therapy. Twenty percent of sites lost 2 mm in the poor OH group in both surgical and non-surgical groups, compared to only three percent of sites in the good OH group. The authors concluded that an equal response can be achieved for pockets > 3 mm with both surgical and non-surgical therapy, and that the patient's OH and quality of SRP are critical for the long-term success of periodontal therapy.[24]

Similar findings were reported in subsequent studies that compared SRP, gingivectomy, APF with or without OS, and MWF with or without osseous recontouring (OR) over a 12-month follow-up.[25-27] Lindhe

et al. compared SRP, MWF, and Modified Kirkland Flap (KF) using a split mouth design in 15 patients followed for one year. SRP was found to be as effective as the surgical procedures, with similar gains of CAL following therapy, despite more sites with > 7 mm PD remained after SRP. Granulation tissue removal was also shown as not being critical for proper healing conditions after flap surgery, since the granulation tissue was not removed during surgery. No differences were found in PD reduction or CAL gain between the surgical and non-surgical methods.[25]

Table 2. European studies.

LOCATION	AUTHOR	COMPARISION	YEARS	RESULTS
SWEDEN	Rosling et al. (1976)	APF, MWF w/ and w/o OR	2	**More CAL gain:** Associated with better OH
	Lindhe et al. (1982-I)	SRP, SRP+MWF	2	**MWF:** more PD reduction and higher CAL gain
	Lindhe et al. (1982-II)	Critical Probing Depths	2	**CPD:** SRP =2.9 ± 0.4 mm, MWF = 4.2 ± 0.2 mm
	Rosling et al. (1983)	APF, MWF w/ and w/o OR	4	**Good OH:** No ≠ b/w groups
	Lindhe et al. (1984)	SRP, SRP+MWF	5	**PD reduction and CAL gain:** No ≠ b/w groups **More PD reduction and more CAL gain:** with better OH
	Lindhe et al. (1985)	SRP, MWF, KF	1	**PD reduction and CAL gain:** No ≠ b/w groups **Granulation tissue removal**: Not critical for proper wound healing
DENMARK	Isidor et al. (1984)	SRP, MWF, APF	1	**CAL gain:** Similar for all groups, slightly increase for SRP
	Isidor et al. (1986)	SRP, MWF, APF	5	**PD reduction and CAL gain:** No ≠ b/w groups **CAL loss:** < 5% of the sites

OR: Osseous Recontouring; MWF: Modified Widman's Flap; SRP: Scaling and Root Planing; OH: Oral Hygiene; CPD: Critical Probing Depth; APF: Apically Positioned Flap; KF: Modified Kirkland Flap; PD: Probing Depth; CAL: Clinical Attachment Level; BOP: Bleeding On Probing.

Using regression analysis of published data, Lindhe et al. (1982) described the "critical probing depth"(CPD) for which periodontal therapy resulted in either gain or loss of CAL. The CPD for SRP was 2.9 ± 0.4 mm, and the CPD for MWF was 4.2 ± 0.2 mm. They suggested that for patients with a large number of shallow PD sites, non-surgical therapy would be more beneficial, while in patients with a large number of sites > 4.2 mm, surgical treatment may lead to more CAL gain.[22]

Danish Studies: Isidor and Karring (1986) compared SRP, MWF, and APF in 16 patients followed for five years. No OS was performed. During the first and second week after surgery or SRP the patients rinsed twice daily with 0.2% chlorhexidine digluconate. Patients were recalled every 2 weeks for the first year, every 3 months for the second year, and every 6 months for the remaining three years. The results indicated that less than 5% of the tooth surfaces exhibited CAL loss > 2mm, or loss of alveolar bone ≥ 15% after 5 years. No significant differences were found between the treatment methods in any of the observed clinical parameters. Both surgical and non-surgical treatment resulted in PD reduction that was sustained for five years. Also, no relationship was found between the patient's level of OH and CAL loss, suggesting that frequent SPT interval was more important in the long-term success of treatment.

DISCUSSION

Interpretation of the results of various longitudinal clinical trials is complicated by several factors. The studies didn't have the same experimental design, the therapeutic protocols were not standardized, and the methods of data collection were different. Other points of difference are summarized in Table 3.

Table 3. Study design of American and European studies.

Comparison	American Studies	European Studies
Measurement sites	4 points at line angles (not deepest part)	6 sites/tooth (deepest part)
Study teeth	Molars and single-rooted teeth	Single-rooted teeth
Maintenance	3-month SPT (professional maintenance more important than patient OH)	2-weeks at first (OH and maintenance equally important in some studies)
Unit of analysis	Patient	Site
Occlusal adjustment	Some studies (MI)	No
Probe type	Not uniform	Not uniform
Power calculation	Not performed	Not performed

Age: The effect of age on the periodontium was possibly overlooked in the various longitudinal clinical trials since subjects with wide age ranges were recruited. Aging has been proposed to result in a variety of periodontal changes, such as increased periodontal breakdown, accompanied by a slower rate of wound healing.[56] However, these phenomena are overshadowed by the patient's susceptibility to periodontal disease. Lindhe et al. compared the healing capacity of subjects with different ages and failed to demonstrate a difference between the different age groups.[57]

Oral Hygiene: An inconsistency regarding the effect of personal OH on the results of treatment appears to exist when comparing different studies. The Minnesota, Michigan, and Denmark studies reported patients with imperfect OH responded equally as well, in terms of CAL, as patients with high OH scores. However, Swedish studies reported that plaque-free sites did not lose attachment while plaque-associated sites tended to lose attachment. The discrepancy may be related to the differences in the maintenance protocol implemented in these studies. The Swedish studies performed only supragingival tooth cleaning at maintenance visits, while the Minnesota, Michigan, and Denmark studies performed subgingival debridement during SPT. The subgingival scaling may aid in disrupting the subgingival ecosystem and reducing the pathogenicity of the microflora, thereby minimizing CAL loss even in the presence of imperfect patient's performed OH.

Smoking: Periodontal disease seems to be more prevalent in smokers than in nonsmokers.[58] Studies have reported decreases in gingival blood flow due to smoking.[59] Smoking may also increase the presence of periodontopathogens due to the diminished oxygen intake.[60] Both the chemotaxis and the phagocytic capacity of the polymorphonuclear leukocytes (PMNs) harvested from smokers are lower than with those harvested from nonsmokers.[61] Furthermore, smokers have lower IgA, IgG, IgM, and suppressor CD8 lymphocytes levels than nonsmokers.[62] These differences between smokers and nonsmokers should be taken into account by clinicians when evaluating periodontal therapy and the healing process.[58-60,62] Preber and Bergstrom (1990) found that smokers have significantly less PD reduction after surgery due to impairment of the healing process caused by smoking.[63]

Efficacy of Non-surgical Therapy in Deep Pockets: Since successful non-surgical therapy is dependent on thorough root debridement, factors that may influence success need to be addressed. Several studies have investigated the limits of closed SRP. Waerhaug evaluated the response to subgingival plaque removal on 84 teeth that were extracted after subgingival instrumentation. He noted that 90% of teeth had remnants of plaque in ≥ 1 surfaces. Reestablishment of the dento-epithelial junction (DEJ) was possible if all the plaque was removed. The DEJ was reestablished in 83% of < 3 mm pockets, 39% of 3 to 5 mm pockets, and only 11% of the time if pockets were > 5 mm. Waerhaug therefore recommended pocket elimination for ≥ 3 mm pockets.[64,65] Rabbani et al. examined 62 teeth treated with SRP before extraction for the percentage of residual calculus related to initial PD. A high correlation between increasing PD and residual calculus was found. In pockets ≥ 6 mm, 37% of root surfaces had residual calculus, as opposed to 21% in 4 to 6 mm pockets, and 8% in 1 to 3 mm pockets. No difference was found between anterior and posterior teeth.[66] Stambaugh et al. calculated the "curette efficiency" (the average PD instrumented to a plaque and calculus free surface which was hard and free of gouges and scratches) to be 3.73 mm. They also reported the "instrument limitation" (the maximum mean PD at which evidence of instrumentation could be seen) to be 6.21 mm.[67] This highly quoted study, however, was a descriptive study that examined 7 posterior teeth only. Attempts to increase the efficacy of SRP in deep pockets have included the use of fiber optic illumination, accompanied by papillary reflection.[68,69] Improved efficacy was noted with both methods. Shen et al. evaluated the results of SRP following pocket distention with retraction cords for thirty minutes. The study included 75 teeth in 15 patients with PD between 5 and 10 mm. There were significant reductions in percentage of residual calculus after the use of retraction cords.[70]

Caffesse et al. evaluated SRP efficacy with and without surgical access. A correlation between increasing PD and residual calculus was also found. Complete root cleaning was possible 83% of the time in 1 to 3 mm pockets, 43% of the time in 4 to 6 mm pockets, and 32% of the time in ≥ 7 mm pockets. Surgical access improved calculus removal in the 4 to 6 and ≥ 7 mm pockets. However, 24.3% of 4 to 6 mm pockets and 50% of ≥ 7 mm pockets still had calculus after surgical access. Most of the residual calculus was found at the cemento-enamel junction (CEJ), or in association with grooves, fossae, or furcations.[71] Again, no significant differences were found between anterior or posterior teeth. Fleischer et al. found significantly more calculus-free root surfaces on multi-rooted teeth with surgical access, but

deposits were still left on many teeth (22% of all surfaces; 45% in > 6 mm PD) even with surgical access, and neither approach was highly effective in furcation areas.[72] Waerhaug cited bleeding that obscures the surgical field, and the fact that the plaque front and the tooth are of the same color as reasons for the failure of complete calculus removal with flap surgery.[73]

The significance of complete root debridement on arresting periodontal disease may be somewhat questioned by the improvement in clinical parameters achieved by SRP in the longitudinal studies. Although plaque and calculus were routinely left after therapy, periodontitis was arrested with closed SRP in many studies. This may suggest a range of incomplete debridement compatible with periodontal health.[74] Cobb cites observations by Sherman et al., and Kepic et al. of reduced calculus volumes, rather than presence or absence, as possible explanations of this apparent paradox.[75-78] Cobb suggested a calculus "critical mass" concept similar to that of plaque that is compatible with periodontal health.[75] The alteration of subgingival microflora caused by SRP may also explain the improvement in clinical parameters associated with SRP.[79] Care should be taken not to conclude that complete debridement is not necessary, since studies have shown that all teeth lost to periodontal disease had heavy residual calculus deposits.[10,13,54,73]

Soft Tissue Management: Results of the longitudinal studies suggested that SRP were as effective as surgical procedures in arresting destructive periodontitis, and that thorough SRP was the critical determinant of success.[74] Interpretation of these results led to the development of "soft tissue management programs" for the treatment of periodontitis. Attempting to clarify misunderstandings about this concept, a position statement was issued by the AAP in 1996.[80] Soft tissue management was defined as "the administration of non-surgical therapy to patients undergoing active treatment for some form of periodontal disease". The procedure may consist of a combination of OHI, manual and/or mechanical SRP, delivery of local and/or systemic chemotherapeutic agents, and elimination of contributing factors. The position statement indicated that while SRP may resolve inflammation and arrest disease progression in some patients, in others it may not. For these patients, surgical resective or regenerative therapy may be necessary. It was also pointed out that before SRP is selected as the definitive mode of therapy, its limitations must be understood. Clinicians must critically appraise their ability to meticulously debride deep pockets, and appreciate the skill level and time required for such treatment. Greenstein cited that "the length of therapy and the skill level of the therapist are critical determinants of successful SRP".[74]

Efficacy in Furcation Areas: Furcation areas present some of the greatest challenges to the success of periodontal therapy.[81] Higher mortality and compromised prognoses for molars with furcation involvement have been reported in several retrospective studies of tooth loss.[10,82,83] Ramfjord et al. reported that 16 of the 17 teeth lost during the maintenance phase in the latest Michigan longitudinal study had furcation involvement initially.[10] Reasons for compromised results in furcation areas include lack of proper access for instrumentation due to furcation anatomy and, therefore, persistence of pathogenic microbial flora.[75] Resective and/or regenerative surgical therapies have consequently been predominantly employed in treating furcation areas. As a result, few studies are available to assess the response of furcation sites to

SRP. Decreased clinical response to SRP has been reported.[43,84,85] However, Wang et al. found molar teeth with furcation involvement are more likely to lose CAL than molar teeth without furcation involvement, regardless of the method of therapy.[86] Also, Wylam et al. found no statistical difference with respect to effectiveness of calculus removal in furcations between closed (93.2% residual plaque and calculus) and surgical access (91.1%).[87]

Skill Level of the Therapist: SRP procedures are technically very demanding and time-consuming.[19] Since the success of periodontal therapy is dependent on thorough debridement, the ability of different clinicians with different skill levels and training backgrounds to predictably achieve successful results can't be expected to be the same. Although Badersten et al. found only small differences in clinical results with various experience levels, studies by Brayer et al. and Fleischer et al. found that experienced operators were more proficient in removing calculus in furcations and deep pockets than those with less experience.[40,72,88] Also, successful results by the longitudinal studies were achieved after an average of 10 minutes or more per tooth was spent delivering non-surgical therapy.[74] These factors need to be critically appraised before SRP is chosen as the definitive mode of therapy.[80]

Long-term Maintenance: Results of the longitudinal studies demonstrated that SRP resulted in stable CAL gains, but unpredictable PD reduction. Several authors have investigated the significance of shallow PD on periodontal health. The 1989 World Workshop in Clinical Periodontics concluded "no study has been able to substantiate the concept that pocket elimination or reduction surgery is mandatory for the success of therapy or for easy maintenance on a long-term basis". Furthermore, in a retrospective study of pocket formation after three years of SPT, Halazonetis et al. showed that many surgically eliminated pockets tended to recur after treatment.[89] Deep pockets are associated with more BOP, increased recolonization of pathogenic bacteria, reduced efficiency of supragingival plaque control, and increased probability of disease progression.[47,90-92] However, successful maintenance of CAL of all PD categories through regular maintenance visits of similar duration (1 hour) has been established through the various longitudinal studies. Also, individual probing depths were not found to be good predictors of future attachment loss.[47] Greenstein has therefore made the conclusion that shallow probing depths are a desirable, but not always an essential, treatment outcome.[93]

CONCLUSION

Although a comparison of surgical and non-surgical periodontal therapies may provide an interesting academic discussion, the prudence of such a comparison is highly arguable. Reliance on empirical therapy for the treatment of a disease with multiple clinical presentations and a variety of contributing factors that are not always the same for all patients, such as the case with chronic periodontal disease, is not appropriate. According to the current knowledge of long-term treatment of chronic periodontal disease, a guideline for the decision-making process involved in selecting the type of therapy is suggested (Table 4). SRP, surgical resective and/or regenerative procedures, and antibiotic therapy are available therapeutic modalities that should be used in different combinations for individual patients and/or sites as needed to achieve the

ultimate goal of periodontal therapy: "The maintenance of teeth in a state of health, function, comfort, and acceptable esthetics, and the regeneration of lost periodontal structures where indicated".[1]

Table 4. Decision making for surgical and non-surgical treatment of chronic periodontal disease*

Factors	SRP	Surgery
Age		
> 70	+	-
< 40	-	+
Hygiene-Poor	+	-
Smoking		
1/2-2 packs	+	- -
> 2 packs	+	- - -
Significant systemic disease	+	- -
Pockets < 6 mm	++	- -
Pockets > 7 mm	+	++
Inflamed edematous gingiva	++	- -
Fibrous gingiva/deep pockets	-	+
Hyperplastic gingiva	-	+
Furcations ≥ class II	+	++
Restricted access root anatomy	+	++
Failure of previous SRP	+	++
Refractory disease	+	-
Calculus:		
-Discrete/"chunky"	+	-
-Diffuse/embedded	+	++
Hypercementosis	-	++

* **(+):** Recommended **(++):** Strongly recommended
(-): Not recommended **(--/---):** Strongly not recommended

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