Evidence-Based Approach for Treatment Planning Options for the Extensively Damaged Dentition

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ABSTRACT

Restoring the extensively damaged dentition has always been a difficult decision-making process for the dental practitioner. Decisions to restore these teeth were primarily based on the fact that "fixed" teeth are typically better functionally than "removable" teeth and better esthetically than "no" teeth. Prior to dental implants, restoring missing teeth and extensively damaged teeth utilizing traditional therapy such as crown lengthening, root hemisection/amputation, endodontic therapy, apical surgery, post and cores and splinting were the options available to our patients. These teeth typically required the expertise of additional specialist, however their prognosis and success rates were typically guarded at best. Presently, dental implant success rates have been clearly identified and documented in the literature which now questions the survivability and success rates of the traditional mode of therapy for extensively damaged teeth. This paper will attempt to review the dental literature for various traditional modes of therapy for restoring the extensively damaged to provide a consensus of their survivability to help the practitioner to present options and prognosis for their patients.

Technological advancement in dentistry has allowed the practitioner to re-evaluate traditional modes of dental therapy for the extensively damaged dentition. These advancements in dentistry have given us better options to restore the dentition without compromising the remaining teeth and periodontium. Devan stated that "our aim must not merely be the meticulous restoration of that which is missing but the perpetual preservation of that which remains." This statement has had various interpretations during the evolutionary process of dentistry and is dictated with materials and technology available at that period of time.

Extensively damaged teeth or periodontium would typically require multiple dental procedures that physically weakened the teeth or decreased the periodontal support for survivability of the remaining teeth, but did provide for tooth restoration and replacement

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Figure 1a. Radiographs reveal localized vertical bone loss on distal root on No. 19 with missing teeth Nos. 22, 23, and 24.

Figure 1b. Restoration of root amputation of No. 19 with rigid connection between Nos. 18 and 19 and nonrigid connection to FPD Nos. 20-27.

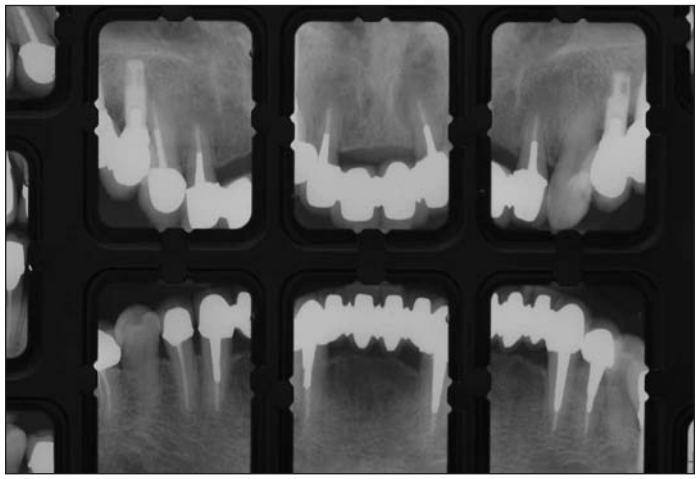

Figure 2. Endodontically treated abutment teeth supporting multiple-unit fixed partial dentures.

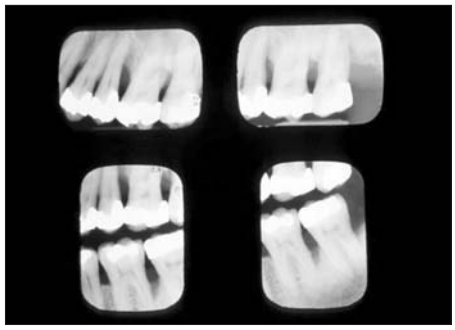

Figure 3a. Radiograph reveals poor prognosis for teeth Nos. 13 and 15 with guarded prognosis on tooth No. 14.

Figure 3b. Distal root amputation and root canal therapy on tooth No. 14 utilized as a distal abutment for a four-unit fixed partial denture on Nos. 11-14 with nonrigid attachment connection to splinted fixed restorations on teeth Nos. 7-10.

(**Figure 1a**). Such examples include, full coverage esthetic crown restorations, endodontic therapy with post and cores, root amputation/hemisection, and osseous surgical periodontal therapy (**Figure 1b**). These accepted traditional modes of therapy were utilized to restore extensively damaged or missing teeth however their survivability or success rates have now come to issue because of improved alternatives to treatment.

The advancement of dental implants has made an impact on treatment planning for missing and extensively damaged teeth, however many practitioners were hesitant (as they should be) to provide this new type of treatment since they were reasonably confident and comfortable that the traditional methods of replacement and restoration could provide some years of service. Langer and Sullivan have stated that "traditional clinicians would initially reserve the use of implants for the category of desperations and were recommended as a last resort, intended for patients disabled by previous dental experiences or unable to wear conventional removable appliances."[1] As implant success rates reported 85 percent to 95 percent, and implant education became more readily available, conventional treatment planning techniques are less likely to attempt some of the older heroic and less predictable technique.

It is generally accepted that patients prefer teeth than to being edentulous. Given this statement, the clinician's option for restoration for the missing or extensively damaged dentition required crowns, fixed partial dentures or removable partial dentures (**Figure 2**). Crowns and fixed partial dentures were considered state of the art for tooth replacement and restoration, which is significantly better than the

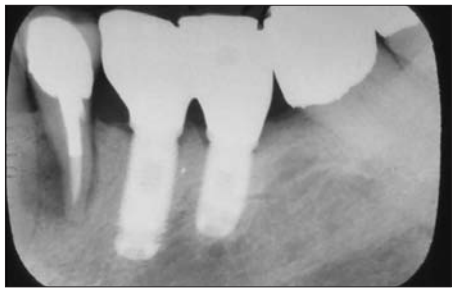

Figure 4. Root fracture of endodontically treated tooth No. 21 that was previously an anterior abutment for a four-unit fixed partial denture. Implants were placed in Nos. 19 and 20 when there were no radiographic lesions for tooth No. 21.

Figure 5a. 1990 periapical radiograph with apparent intact periodontium.

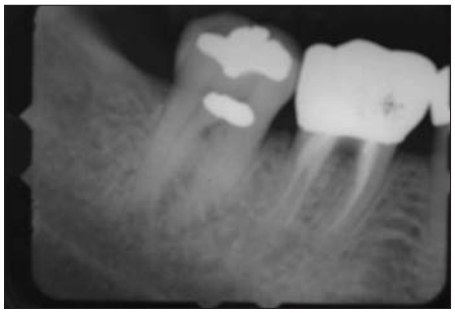

Figure 5b. 1994 periapical radiograph with radiographic furcation lesion.

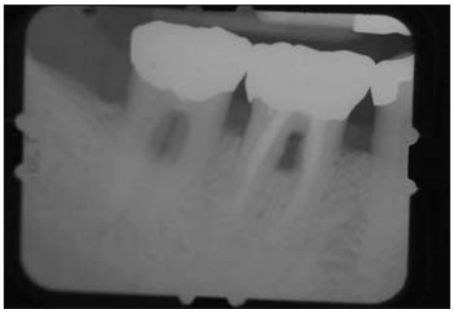

Figure 5c. 1999 periapical radiograph with significant radiographic furcation lesion. Tooth No. 31 crown restoration was done in 1997 due to a possible cracked tooth causing the bone loss as surmised by the periodontist.

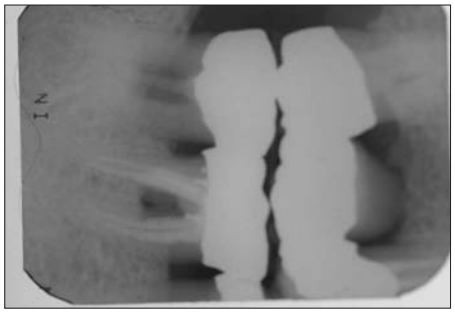

Figure 5d. 2002 bitewing radiograph with minimal changes compared to 1999. Patient has excellent oral hygiene since 1990 and has periodontal hygiene maintenance every three months.

alternative of removable partial dentures, complete dentures, and to no teeth at all. Therefore, the clinician typically planned other adjunctive procedures such as root canal therapy, post and cores, osseous reduction and hemisections or amputations in order to support splinted crowns and fixed partial dentures as the alternative (removable prostheses) was always considered less acceptable when it came to function, sometimes esthetics and socially (**Figures 3a-b**). The "heroic" type of adjunctive procedures gave the ability to place restorations but the longevity was always questionable however, it was considered the best treatment available. With the long-term success rates of implants, we must now re-evaluate the success rates of traditional modes of therapy and evaluate their long-term success.

Restoration of Endodontically Treated Teeth

Endodontically treated teeth contain approximately less than 9 percent moisture content than nonendodontically treated teeth.[2] It is postulated that due to the decrease in moisture content, the teeth are inherently more brittle and therefore can be more susceptible to fracture. A study by Carter et al. has indicated that dentin from endodontically treated teeth exhibits significantly lower shear strength and toughness than dentin from vital teeth.[3] Several authors have stated root canal therapy success rates can range as high as 70 percent to 95 percent or as low as 64 percent to 75 percent, depending upon training and experience.[4,5]

Goodacre and Spolnik reviewed literature for prosthodontic management of endodontically treated teeth and found the incidence of endodontic treatment required after tooth preparation has ranged from 3 percent to 23 percent and fixed partial dentures with complex prostheses had higher incidence rates than single crowns.[6] The incidence is higher when the prepared teeth have deep carious lesions and when periodontal disease has resulted in considerable bone loss which is characteristic for extensively damaged teeth.[6] Other studies have evaluated endodontically treated teeth for FPD or RPD abutments and found that these teeth had a greater failure rate than nonsurgical root canal therapy for single crown restorations.[7] Reasons for endodontic failures can be due to microleakage after post space preparation, microleakage after post cementation, leakage during provisional restorations and leakage with the permanent restorations.[8] Turner has reported 100

Table 1

Conservative Surgical and Nonsurgical Therapy, Molars With Furcation Involvement (Carnevale et al.)

Author	Years	No. of teeth	% Success	% Teeth lost
Hirschfield, et al., 1978	15-53	1464	69	31
Ross and Thompson, 1978	5-24	38	88	12
Wood, et al., 1989	10-34	164	77	23
Goldman, 1986	15-34	636	56	44
McFall, 1982	15-29	164	43	57
Wang, et al., 1994	8	87	70	30

Table 2

Root Resection Therapy in Molars With Furcation Involvement (Carnevale, et al.)

Author	Years	No. of Teeth	Success %	Failure %
Bergenholtz, 1972	2-10	45	*	6
Klavan, 1975	3	34	97	3
Langer, et al., 1981	10	100	*	38
Erpenstein, 1983	4-7	34	80	20
Buhler, 1988	10	28	*	32
Carnevale, et al., 1991	10	488	94	6

*Author unable to calculate percent success rate with given data

Figure 6a. Tooth No. 3 with mesial buccal root amputation and root canal therapy. Prefabricated post was placed and composite build-up, portion of the composite build-up fractured prior to final impression appointment.

Figure 6b. Gingival view of restorations for tooth No. 3. Mesial buccal pontic form was designed to help guide proxy brush into the mesial area of the palatal and distal root as well as distal to tooth No. 4.

failures of post retained crowns and stated that post loosening was the most common type of failure.[9] Sorenson and Martinoff's retrospective study on 1,273 endodontically treated teeth found 36 post and cores failed out of 420, which was due to post and core dislodgement and tooth fractures[10] (**Figure 4**). It can be summarized that the greater amount of tooth structure remaining after root canal treatment can increase the longevity of that restoration.

Restoration of Periodontally Involved Teeth

Traditional periodontal therapy involves resolution of the inflammatory process of the periodontium. This typically involves elimination of soft and hard deposits from the surfaces of the tooth via scaling and root planning and sometimes combined with periodontal surgery involving pocket reduction (soft or hard tissues), tunnel preparations and or root hemisection/amputation.[11] Many of these procedures will improve the local environment by eliminating the causative microorganism but the price one pays is decreased tooth support or tooth strength. Björn et al. reported that if periodontal defects go untreated, signs of bone loss in the furcation area can increase from 18 percent to 32 percent over a 13-year period[12] (**Figures 5a-d**).

Surgical and Nonsurgical Therapy, Molars With Furcation Involvement

There is a wide range of success rates and years of study reported for surgical and nonsurgical therapy involving molars with furcation involvement ranging as low as 56 percent to as high as 88 percent[11] (**Table 1**). The Ross et al. study evaluated 387 maxillary molars over a five- to 24-year period and found

Figure 7a. Fifteen-year-old six-unit anterior fixed partial denture with missing teeth Nos. 7, 8, 9, and 10 with abutments on Nos. 6 and 11. Tooth No. 6 abutment was previously endodontically treated and is currently loose.

Figure 7b. Preoperative periapical radiograph of tooth No. 6 reveals the fact that tooth No. 6 abutment is loose. Upon removal of the restoration, the coronal structure of tooth No. 6 was fractured.

tooth mortality was 12 percent with furcation defects treated via nonsurgical and surgical means.[13] Goldman et al. found after a 15- to 34-year period of maintenance and conservative treatment of 636 furcation involved, 44 percent of the teeth were lost.[14] Hirschfield et al. and McFall's studies reported results similar results where the multi-rooted teeth with furcation involvement had a higher percentage of tooth mortality compared to that of single rooted teeth.[15,16]

Root Resection

Root resection/hemisection techniques were reserved for multi-rooted teeth that had furcation involvement due to moderate to severe bone loss. These teeth would require root canal therapy, osseous surgery and post placement in order to restore with crown restorations (**Figures 6a-b**). **Table 2** shows numerous authors on the treatment of root resection therapy in molars with furcation involvement with their percent failure which ranged from 3 percent (Klavan) to as much as 38 percent (Langer et al.).[11] Longer periods of evaluations typically revealed higher percentage of failure such as Langer's and Erpenstein's study.[17] Langer et al. involved a 10-year retrospective study and reported 38 percent failure, where 16 percent of the teeth were lost in the first five years and the remaining 84 percent were lost between five and 10 years.[18] The dental literature has reported variable success rates among authors. Variability in the reported results has been rationalized that periodontal procedures are very technique sensitive, oral hygiene must be excellent and the restoration must be performed with correct restorative expertise.[19] Typical failures associated with root resection involve root fracture, caries, periodontal problems, abutment and root fractures (**Table 2**).[11]

Long-Term Fixed Partial Dentures

Dental literature has had divergent results for documenting successes or failures with fixed partial dentures. The reason is the difficulty in performing randomized clinical trials with dental patients, non-standardized methodology and trial conduct, varying periods of follow-up evaluation and nonstandard definition of failure. Due to these differences, it is very difficult to assess the overall effectiveness of fixed partial denture therapy. Many of the studies were performed without control groups and therefore, are prone to bias and may show generally too-positive effects of treatment. However, systematic reviews including nonrandomized clinical trials can provide some evidence for prognosis.[20] Scurria et al. have identified eight studies since 1960 and were able to utilize a meta-analysis of fixed partial denture survival. "When failure was defined as removal 92 percent and 75 percent of the FPD's were estimated to survive at 10 and 15 years, when a broader definition of failure was used, namely, combining FPD's removed with those that technically failed and needed replacement, 87 percent and 69 percent were estimated to survive at 10 and 15 years. Abutment survival at 10 years was estimated to be 96 percent."[21]

The hypothesized contributing factor for the various divergent data presented in the literature could be due to the increased mean age of the patient population requiring these dental procedures. Older population of patients may be on medications which may have side effects of depressed salivary function and possible decreased motor coordination leading to worse oral hygiene. Nonuniform definition of failure as well as varying operator skill has also been reported to be contributing factors for the range of data presented.[22]

Failures associated with traditional therapy can be classified as biologic failures and mechanical failures. Biologic failures are caries, coronoradicular fracture, root fracture periodontal disease and apical lesions. Mechanical failures involved loss of retention with the retainer and or post and cores, porcelain fracture and metal fracture[23] (**Figures 7a-b**). One of the problems with defining failure is which mode of failure occurred first? Did the retainer or post become loose and then caries followed? Or did the caries occur first and then cause the loosening

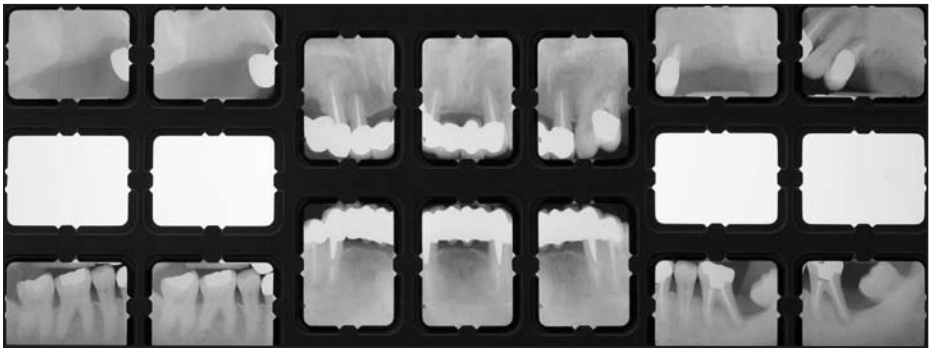

Figure 8a. Preoperative periapical radiograph exhibiting multiple missing teeth, multiple root canal therapy with posts, multiple fixed partial dentures with a distal cantilever on No. 5, extruded molars on teeth Nos. 30 and 31, endodontically treated tooth No. 12 with periapical radiolucency, endodontically treated tooth No. 19 with localized vertical defect on the distal with radiographic furcation involvement and severely mesially tilted third molar tooth No. 17.

Figure 8b. Right-side view of the patients preoperative restorations. Note that tooth No. 29 does not have any restorations.

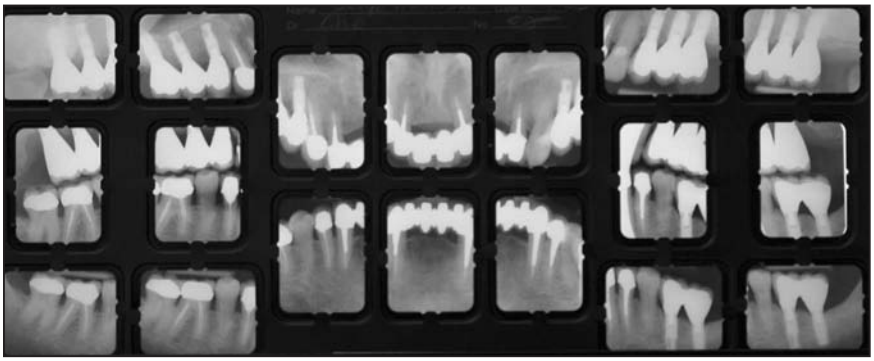

Figure 8c. Periapical radiographs of completed treatment. Nos. 12 and 17 were extracted, some post and cores were replaced and implants were placed the edentulous areas.

Figure 8d. Right-side view of the patients completed restorations. Note that tooth No. 29 was maintained without restorations.

of the retainer or fracture of the post or tooth? Regardless which occurred first, the fact remains that extensively damaged teeth have been traditionally utilized to support and retain restorations under difficult circumstances involving compromised support and minimal remaining tooth structure.

Hammerle et al. studied long-term analysis of biologic and technical aspects of FPD and cantilevers and show a close correlation between loss of retention and carious lesions. Ten percent lost vitality, 1 percent showed periapical pathology, 8 percent developed secondary decay, 8 percent lost retention, material fracture occurred 1 percent to 3 percent of the abutment teeth, and fracture of abutment teeth amounted to 3 percent and was twice as frequent at abutments adjacent to cantilevers compared to abutments not adjacent to cantilevers.[24] These problems may be at least partially avoided by performing optimal plaque control and by strictly observing the rules for preparation of retentive FPD abutments.[24] Similarly, Randow et al. evaluated technical failures and complications for extensive fixed prosthodontics and reported a positive correlation between the number of failures and cantilevers.[25] Glantz et al. assessed the quality of fixed prosthodontics and found a cumulative success rate of 68 percent over a 15-year period.[26] It appears the common destructive element in the extensively damaged has been biomechanical failure of the prosthesis and its underlying root structure and by the nature of the problem, the solution for extensively damaged teeth has been limited at best.[27]

Implants

The advantages of dental implants are the replacement of missing teeth without the necessity of altering adja-

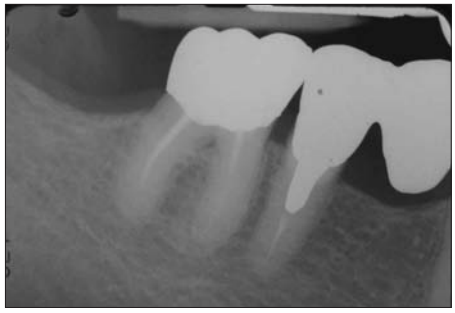

Figure 9a. Preoperative periapical radiograph revealing inadequate root canal therapy on tooth No. 30, root canal therapy on tooth No. 29 with large post and is distal abutment for three- unit fixed partial denture and the anterior abutment also is endodontically treated with a post and core.

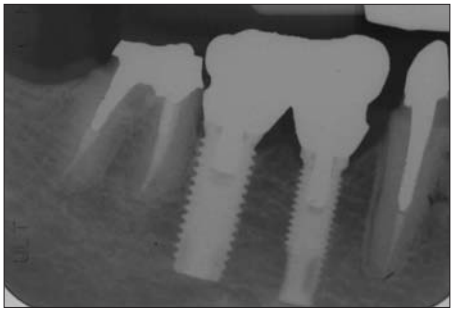

Figure 9b. Periapical radiograph revealing that tooth No. 29 was removed and implant were placed in tooth No. 29 and No. 28 position while teeth No. 27 and No. 30 were endodontically retreated with placement of new post and cores.

Figure 9c. Right-side view exhibiting the crown restorations on teeth and implants opposing an implant supported and retained maxillary overdenture.

cent healthy or extensively damaged teeth, providing occlusal support and function similar to natural teeth and esthetics. The disadvantages of dental implants are increased cost, increased treatment time and surgical procedure. The survival rates for implants have been well documented in the dental literature and should be presented for an option for missing teeth as well as replacement for extensively damaged teeth.

Brånemark and Adell initially reported implant success rates for edentulous jaws of 91 percent for the mandible and 81 percent for the maxilla in the late 1970s and early 1980s.[28,29] In the early 1990s, Henry et al. reported similar success rates for implants placed in partially edentulous jaws as those found by Brånemark and Adell.[30] Other studies by Brånemark and Albrektsson suggest implant cumulative survival rates ranging from 95 percent to 99 percent for the mandible and 85 percent to 90 percent for the maxilla for edentulous jaws.[31,32] More recent studies utilizing meta-analysis of implants in partially edentulous jaws report survival rates of 94 percent for implant fixed partial dentures and 98 percent for single crown restorations after a six- to seven-year period.[33] Implant survival rates utilizing standard life table principles has reported similar success rates for maxilla and mandible and reported survival rates of 95.6 percent for implant supporting tooth prostheses and 96.1 percent for cantilever fixed partial prostheses.[34]

The plethora of implant survival rates reported in the dental literature show favorable cumulative survival rates ranging from the low to high 90s and therefore should be a viable treatment plan option for any missing and extensively damaged teeth.

Conclusion

It appears implants can solve many of the shortcomings of traditional therapy. Implants are resistant to decay, mechanically stronger than teeth that are endodontically treated and have had post and cores and do not utilize adjacent teeth for any support or retention to restore missing teeth, and appears to have higher survival rates (**Figures 8a-d**). Extensively damaged teeth typically would require endodontic, periodontic and restorative therapy, and through the present literature, we can inform patients that survivability over the next 10 to 15 years can range from 69 percent to 87 percent as compared to implants which can have an excess of 90 percent to 95 percent survival rate. Restoration of extensively damaged teeth typically have a guarded to poor prognosis because teeth are many times used as abutments for fixed partial dentures or removable partial dentures. These teeth have to support greater numbers of restorations (fixed partial dentures) with less periodontal and structural support. But if implants can be used in conjunction with the extensively damaged teeth, these teeth may have improved prognosis given the fact of additional support by implants (**Figures 9a-c**).

Under ideal conditions, we may approach the 87 percent success rates for restorations, but on the average somewhere between 69 percent and 87 percent may be more reasonable for long-term survivability for restorations. Utilizing the presented success rates for traditional therapy on exten-

sively damaged teeth, it appears that additional treatment and cost may need to be performed within the first 10 to 15 years of service.

The cost of any dental treatment varies widely within North America but implant treatment can range from 1 to 1½ times that of conventional multi-specialty dental therapy. Given the higher percentages for implant survivability, it may not be cost and time effective to attempt multiple specialty procedures on teeth with guarded to poor prognosis. As Langer et al. stated "we had now entered a new arena of treatment (implants) previously unknown to modern dentistry and therefore would now use it out of strength rather than in a state of desperation." CDA

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