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Challenges and success in periodontal plastic surgery

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Abstract

To truly understand a field of study, one must delve into its past and examine the challenges and successes that have shaped its current practices. In the case of periodontal plastic surgery, recognizing how challenges induced changes over the last 70 years—from the 1950s to today—is essential to fully comprehend its evolution. This editorial provides a perspective on the field, highlighting the interrelationships between influential surgical techniques and advancements in research methodology. With each event building upon the last, the evolution of periodontal plastic surgery is a story of scientific progress and ongoing research, fostering a sense of community and shared knowledge.

KEYWORDS
connective tissue, cultural evolution, dental implants, gingival recession, treatment outcome

1 | INTRODUCTION

The love for knowledge, the challenge to push boundaries and the pursuit of success are the driving forces of progress behind research, science, art and life—all with the awareness that success itself is not the ultimate goal, but rather a stepping stone towards another challenge and further advancements. The ongoing challenges and the desire to keep on seeking new achievements were the fundamental elements in the incredible developments in science, medicine and periodontology.

In modern society, dental patients' increasing aesthetic expectations drive the evolution of treatment planning and options in periodontology. This is particularly evident in the treatment of gingival recessions, where obtaining complete coverage of exposed root surfaces and perfect integration of the treated gingiva with the adjacent tissue is essential.

This editorial aims to show how efforts made to overcome the challenges in the treatment of gingival recessions have moved the field forward over the past 70 years (from the 1950s to 2023).

2 | ROOT COVERAGE AND INCREASE IN THE WIDTH OF KERATINIZED TISSUE IN EARLIER STUDIES (1900–1990)

The aspiration to address gingival recessions for reasons such as aesthetics, sensitivity or hygiene has been present for long time. It is worth noting that surgical approaches aimed to displace flaps to cover midfacial gingival recessions were published in early 1900s (Harlan, 1906). A significant contribution was made by the French periodontist P. Rosenthal, whose techniques, originally proposed in 1911, have been of great inspiration for the subsequent approaches (Rosenthal, 1911; Zuhr et al., 2018). The first attempts to systematically develop a successful technique to treat recession defects were performed in the mid-20th century by Grupe and Warren who proposed *the lateral sliding flap* to treat single gingival recessions of lower incisors (Grupe & Warren, 1956). As early as 1956, the authors had already recognized that 'the blood supply of the flap to be used is of great importance', that displaced flaps 'are promising enough to be reported for further development', and were experimenting with variations of techniques in the efforts to reduce complications such as gingival recessions of the donor site (Cohen & Ross, 1968; Corn, 1964; Grupe, 1966; Grupe & Warren, 1956). Despite the popularity of the lateral sliding flap, adjacent donor sites did not always present an ideal gingival phenotype, and the need for gingival augmentation was still a challenge to be met.

Not long after, soft-tissue autografts were introduced. After the first publication by Bjorn (Bjorn, 1963), Nabers described the free gingival graft (FGG) aimed at extending the vestibular fornix and simultaneously increasing the width of the attached keratinized tissue (Nabers, 1966). 'It is hoped that this report will act as a springboard to stimulate interest in the application of free gingival grafts to periodontal problems', Nabers wrote in 1966. Little did he know that his report was going to lead to the development of many modern

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techniques. Further studies contributed to the advancement of our understanding of wound healing (Oliver et al., 1968; Sullivan & Atkins, 1968; Wilderman et al., 1960), and provided valuable insights into case selection, predictability and the potential of the FGG as a single-step procedure for achieving root coverage (Miller, 1985b) (Figure 1).

To improve its predictability for root coverage, Harvey first and Bernimoulin later described a *two-step operation* to coronally position the attached gingiva previously re-established via FGG (Bernimoulin et al., 1975; Harvey, 1970). This novel technique allowed for improved recession reduction, increase of keratinised tissue, preservation of the vestibular depth and reduction of dental hypersensitivity. Simultaneously with the advancements in surgical techniques, the well-known Miller classification was being proposed (Miller, 1985a), aimed at anticipating the prognosis of root coverage after FGG. The four classes by P.D. Miller remained universally used until the latest World Workshop and had the merit of stressing the importance of interproximal tissue height, extrusion and tooth rotation for predictable root coverage. The Miller classification remains today one of the most cited texts in the literature on periodontology, resulting in more than 2000 citations since its publication in 1985 (Table S1). However, the outcomes of FGG for root coverage were often unsatisfactory (McGuire, 1990; Miller, 1987), the aesthetics was sub-optimal and data in support of this technique were lacking. Motivated by the need to overcome the underperformance of the existing techniques, clinicians looked for new ways to improve the outcomes of root coverage.



FIGURE 1 Type 1 gingival recession defect (RT1) of a mandibular central incisor. (a) The treatment was provided in the 1970s–1980s when the gold standard for treating gingival recessions and modifying the gingival phenotype was the free gingival graft technique. (b) Although the treatment resulted in nearly complete root coverage and an increase in the width of keratinized tissue, the aesthetic match with the adjacent gingival sites was not ideal.

In the 1980s, a revolutionary idea emerged that induced one of the most field-changing improvements in the surgical technique of root coverage. With the subepithelial connective tissue graft (CTG), the free connective tissue graft was placed inside instead of outside a split-thickness flap. In this technique, the split-thickness flap was retained to partially cover the CTG, as opposed to being entirely left exposed as in the FGG procedure. As a result, the autogenous soft-tissue graft received nutritional supply from the overlying connective tissue while providing support to the flap. In 1985, Langer and Langer used the CTG underneath a pedicle flap to improve root coverage, reduce the risk of recession relapse and minimize palate exposure (Langer & Langer, 1985).

During the same year, Raetzke pioneered the placement of a CTG beneath an envelope flap, avoiding papillae incision and laying the groundwork for modern *tunnelling* techniques (Raetzke, 1985). Not long after, Nelson proposed a modification of the CTG approach, described as *bilaminar grafting* because of the use of two biological layers composed of a free connective tissue graft and an overlying pedicle flap (Nelson, 1987).

E. P. Allen and Miller (1989) concluded the decade by presenting a simplified technique to correct shallow recessions with favourable tissue phenotype by utilizing a coronally advanced flap (CAF) of the existing gingiva, incorporating triangular surgical papillae, without the need for supplementary autogenous soft-tissue grafts (E. P. Allen & Miller, 1989). This approach, although limited in a similar fashion to the lateral pedicle flap, provided the basic feature of the most current root coverage procedures.

3 | THE GRAFT–TOOTH INTERFACE AND THE QUEST FOR PERIODONTAL REGENERATION (1990–2000)

As the clinical outcomes of the treatment continued to show improvement, researchers developed a keen interest in understanding the nature of the graft–root interface and how this biological connection influenced the success of root coverage procedures. Research on wound healing after plastic interventions clarified that a long junctional epithelium existed between the root and the flap/graft and that only a modest area of connective tissue attachment could be expected (Pasquinelli, 1995). The development of ethical regulations that restrict human histology research has also been a contributing factor to the limited investigations in this field.

Simultaneously, the revolutionary ideas of guided tissue regeneration (GTR) on the periodontal ligament cells were being clinically

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applied in regenerating true periodontal attachment in bony defects (Gottlow et al., 1986, 1992). In that context, some authors applied the *GTR principles* in the treatment of gingival recessions to obtain root coverage and true connective tissue attachment. Pini Prato et al. and Tinti et al., followed by others, were the first to apply barrier membranes with the purpose of achieving recession coverage (De Sanctis & Zucchelli, 1996; Ito & Murai, 1996; G. P. Pini Prato et al., 1992; Roccuzzo et al., 1996; Tinti et al., 1992; Trombelli et al., 1995). Subsequently, histological studies proved the presence of new periodontal attachment on the root coronal to the reference notches (Cortellini et al., 1993; Harris, 2001; Parma-Benfenati & Tinti, 1998). Over the years, the use of GTR principles and materials for recession coverage was abandoned and replaced by better-performing CTG-based techniques. The cost of the materials, the risk of flap dehiscence and the challenging nature of the technique were the main drivers for the change. From a historical perspective, the adoption of improved techniques for flap release and covered healing during the era of GTR had a lasting impact. These advancements served as a crucial foundation for the development of more sophisticated techniques that are utilized in contemporary practice.

As coronally advanced techniques were transitioning from GTR- to CTG-based approaches (G. Pini Prato et al., 1996), researchers in American and European centres were further developing tunnelling designs with its various modifications, describing innovative applications for multiple recession defects (A. L. Allen, 1994; Azzi & Etienne, 1998; Zabalegui et al., 1999).

Towards the end of that decade, the World Workshops held in 1996 and 1999 played a pivotal role in providing a significant stimulus and a contribution to the field of periodontal plastic surgery by classifying mucogingival conditions and offering treatment guidelines (G. P. Pini Prato, 1999; Wennstrom, 1996). The Consensus Report of Mucogingival Therapy in 1996 was particularly noteworthy for its role in stimulating research advancements over the next 30 years. It inspired researchers and clinicians to establish new objectives and ultimately advance the field of periodontology.

4 | TREATMENT OF MULTIPLE RECESSIONS, IDENTIFICATION OF PREDICTIVE FACTORS AND IMPROVED RESEARCH METHODOLOGY (2000–2010)

Until the year 2000, the primary focus of treatment had been addressing localized recessions, with sporadic consideration given to the management of multiple gingival recessions (Langer & Langer, 1985; Zabalegui et al., 1999). However, a new challenge emerged in the 21st century: treating multiple recessions. This stimulated the development of innovative techniques aimed at optimizing the use of the CAF for multiple recession defects. The modified coronally advanced flap (MCAF) for multiple recessions and the split-full-split elevation deserve special recognition (De Sanctis & Zucchelli, 2007; Zucchelli et al., 2003; Zucchelli & De Sanctis, 2000). MCAF, proposed by Zucchelli and De Sanctis in 2000, was a modification of the envelope flap with the addition of unique papillary incisions for better adaptation of the flap margin to the cemento-enamel junction and reduced flap tension. It used oblique submarginal incisions to dislocate surgical papillae from their anatomical counterparts, preventing unfavourable tissue displacement. The omission of vertical releasing incisions further improved vascular supply and aesthetic outcomes. The split-full-split technique, which was applied to single and multiple recessions, allowed for modulation of flap thickness, preserving the periosteum, and achieving better recession reduction outcomes with improved aesthetics. The authors modified the design of the CAF for single recessions from triangular to trapezoidal surgical papillae (De Sanctis & Zucchelli, 2007).

In the same year, attempts to improve the predictability of root coverage procedures continued. In this context, a series of studies investigated key *anatomical and surgical factors* driving clinical outcomes with renewed scientific rigour. Some of these studies focused on CAF-only designs involving vertical releasing incisions, a technique in which wound healing might differ from contemporary practice designs. Nonetheless, their research findings provided crucial insights that significantly advanced the field during that era. In the effort to quantitatively evaluate the anatomical determinants of root coverage, gingival thickness (Baldi et al., 1999), baseline recession depth (Nieri et al., 2009), tooth rotations and abrasions (Zucchelli et al., 2006) were found to affect root coverage outcomes. Investigations of the surgical steps clarified that the flap had to be passively sutured (G. P. Pini Prato et al., 2000), displaced 2 mm or more coronally to the cemento-enamel junction (G. P. Pini Prato et al., 2005), and that the use of *microsurgical principles/armamentarium* led to improved outcomes (Burkhardt & Lang, 2005). Microsurgery was a remarkable addition to the tunnelling (Zuhr et al., 2007) and CAF approaches (Francetti et al., 2005), playing a decisive role in enhancing surgical precision, wound healing and aesthetic outcomes.

The publication of clear research data during this decade was conducive for better interpretations of previous literature and to compare data from various controlled and randomized studies. In these years of scientific excitement, the first systematic reviews integrated the available clinical trials to determine the best performing surgical technique (Cairo et al., 2008; Clauser et al., 2003; Roccuzzo et al., 2002), and follow-up studies documented the long-term outcomes and tissue remodelling after treatment (Agudio et al., 2008, 2009; Trombelli et al., 1995).

As science and knowledge were being applied to clinical practice, complete root coverage (CRC) gradually became more predictable, and a new vision of aesthetics gained value as the ultimate endpoint of plastic surgery procedures (Cairo et al., 2009, 2010; Rotundo et al., 2008). Indeed, 'the achievement of CRC along with soft tissue anatomy comparable and indistinguishable from adjacent tissue should be considered the treatment goal', Cairo wrote in 2009 to present the root coverage aesthetic score (RES) (Figure 2).

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FIGURE 2 Type 2 gingival recession defect (RT2) of a mandibular central incisor. (a) The treatment was provided in the 2000s–2010s with a combination of free gingival graft and growth factors, followed by gingivoplasty. (b) The result of the treatment was complete root coverage and a pleasant aesthetic integration with the adjacent soft tissues.

5 | TREATING COMPLEX CASES AND LONG-TERM RESULTS (2010–2020)

The surgical techniques used for recession coverage had seen significant improvements, leading to more predictable results. These further advancements paved the way for the next decade (2010–2020), which focused on treating more complex cases of gingival recessions that, until then, seemed unlikely to be associated with CRC after treatment. Examples of these cases were the gingival recessions complicated by cervical abrasions, and recessions with interproximal attachment loss (Recession Type [RT] 2; Miller Class III).

Recessions complicated by *cervical abrasions* were known among clinicians for the lower predictability of CRC (Santamaria et al., 2010). To achieve a successful outcome in such clinical scenarios, studies focused first on methodologies to determine the line of root coverage, then tested the efficacy of CAF + CTG techniques on sites with abrasions. Finally, periodontal-restorative techniques were developed to further improve the predictability of CRC and enhance aesthetic outcomes (Cairo et al., 2020; De Sanctis et al., 2020; Santamaria et al., 2009, 2010, 2018; Zucchelli et al., 2006, 2010).



FIGURE 3 Peri-implant soft-tissue dehiscences of mandibular central incisors. A new challenge has emerged in selecting the most suitable and predictable surgical approach to treat peri-implant soft-tissue lesions.

The treatment of gingival recessions with interproximal attachment loss (RT2) was an unresolved challenge for more than 30 years and was approached with graft-based techniques that already proved highly effective in the treatment of RT1-gingival recessions. Clinicians and researchers identified prognostic factors that contribute to obtaining CRC in challenging scenarios, including the most effective techniques and their limitations (Aroca et al., 2010, 2018; Cairo et al., 2012, 2015, 2023; Sculean et al., 2016).

In this decade, clinical research has shown increasing interest in developing and perfecting *more sophisticated surgical techniques*. Examples include, but are not limited to, the treatment of lingual recessions, recessions at molar sites, maintaining vestibular depth after CAF and optimized microsurgical principles (Aroca et al., 2013; de Sanctis et al., 2011; Di Gianfilippo et al., 2021; Franceschi et al., 2021; Mancini et al., 2021; G. P. Pini Prato et al., 2021; Stefanini et al., 2021, 2018; Zucchelli et al., 2012).

Continuous sling suturing and coronally anchored sutures with composites were reported to optimize graft anchorage and facilitate coronal positioning in tunnelling procedures (E. P. Allen, 2010; Aroca et al., 2010; Zadeh, 2011). Vestibular incisions were implemented to minimize stress on the gingival margin (Chao, 2012; Zadeh, 2011). Tunnelling techniques were refined to target location-specific recession defects such as the laterally closed tunnelling approaches specifically developed for addressing single and multiple recessions in the anterior mandible (Sculean et al., 2021; Sculean & Allen, 2018). The trend towards the advancement of outcomes concomitantly with the advancement in techniques appeared very clear in the commentary by Chambrone and Pini Prato (2019).

Over the years, *long-term follow-up studies* were published to assess the sustainability of treatment outcomes and the biological effects of the phenotype on the position of the gingival margin. Researchers provided valuable data on the impact of tissue remodelling, baseline site characteristics, phenotype modification, brushing behaviour and ageing on the position of the gingival margin over time (Barootchi et al., 2019; G. P. Pini Prato, Franceschi, et al., 2018;

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G. P. Pini Prato, Magnani, et al., 2018; Rasperini et al., 2018; Zucchelli et al., 2014). Longitudinal long-term studies have shown the effects of CTG on gingival thickness, width and coverage stability.

During the 2017 World Workshop, relevant information was summarized in a new official classification of gingival recessions, which was proposed and jointly approved by the American Academy of Periodontology and the European Federation of Periodontology. This new classification, named the *2018 Classification of Gingival Recession Defects and Gingival Phenotype*, brought the most relevant prognostic factors into a single diagnostic matrix (Cortellini & Bissada, 2018; G. P. Pini Prato & Di Gianfilippo, 2020; G. P. Pini Prato et al., 2022) to ultimately suggest indications for treatment. Scientific papers were published to define the epidemiology of gingival recessions according to the new classification (Romandini et al., 2020) and to provide guidance on how to use it in clinical and research settings (G. P. Pini Prato & Di Gianfilippo, 2020). Studies are now being conducted to define the reproducibility of the diagnosis according to the new classification of gingival recessions (G. P. Pini Prato et al., 2022).

Last but not least, the current literature features novel and more sophisticated challenges that explore the effectiveness, case selection and limitations of engineered biomaterials such as dermal and collagen matrices, and compares them with traditional approaches including CAF and CAF + CTG (Barootchi, Tavelli, Di Gianfilippo, et al., 2021; Barootchi, Tavelli, Gianfilippo, et al., 2021; Rotundo & Pini-Prato, 2012;

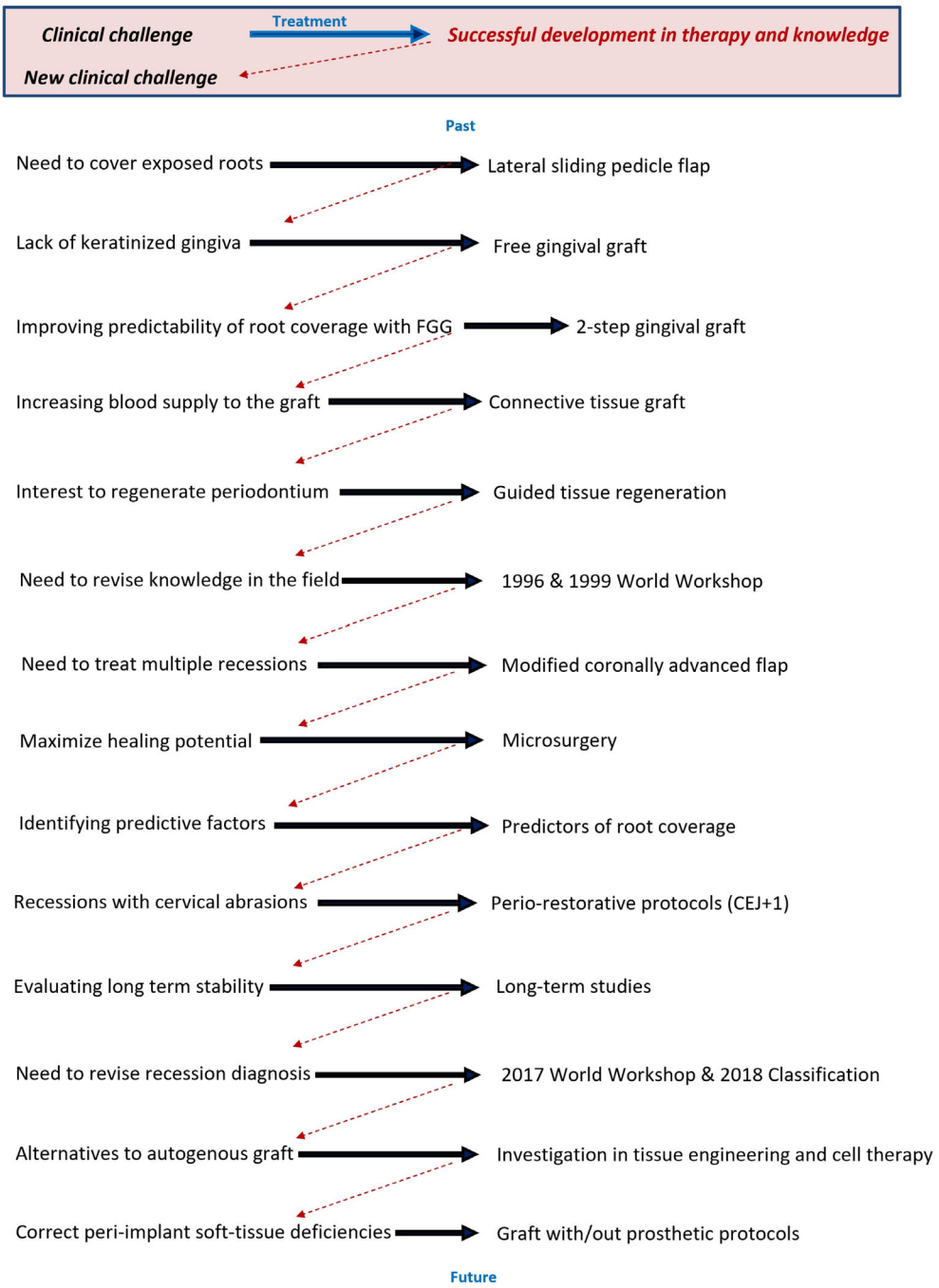


FIGURE 4 The history of periodontal plastic surgery depicted in this figure illustrates how innovation and scientific research have enabled overcoming clinical challenges. Advancements have built upon previous ones to enhance understanding and capabilities, although they have also presented new challenges that offer growth opportunities. Reflecting on this history inspires continuing the tradition of innovation and advancement.

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Tavelli, Barootchi, Di Gianfilippo et al., 2021; Tavelli et al., 2019; Tonetti et al., 2021). These studies are promising and suggest that a new era of investigations on *engineered scaffolds* is about to begin (Tavelli, Barootchi, Rasperini, et al., 2022; Tavelli, Barootchi, Rodriguez, et al., 2022).

6 | THE CHALLENGE OF PERI-IMPLANT SOFT-TISSUE REGENERATION (PAST AND FUTURE)

During the period of 1965 to 1985, clinicians and researchers proved that implant therapy was a reliable treatment option for tooth replacement, initiating a transformative revolution in the field of dentistry. In the 1980s, when dental implants were becoming an established treatment option, *peri-implant soft-tissue dehiscence* was considered a natural occurrence of the implant therapy (Lekholm et al., 1986). It was not until the 1990s that renewed attention was given to the peri-implant soft-tissue phenotype; new challenges arose related to investigating the natural remodelling of peri-implant mucosa (Apse et al., 1991; Bengazi et al., 1996; Oates et al., 2002) as well as techniques to improve the peri-implant phenotype (Price & Price, 1999; Shibli et al., 2004; Shibli & d'Avila, 2006). This was recognized in the *Proceedings of the 1996 World Workshop* which, in its consensus report, stressed 'the role of masticatory mucosa around implants for the maintenance of tissue height/level patient comfort, and aesthetics'' (World Workshop in Periodontics. Section 8, 1996).

In the late 2000s, Burkhardt applied CAF with CTG for the treatment of peri-implant soft-tissue dehiscences (Burkhardt et al., 2008). Although the observed outcomes were suboptimal compared with the coverage obtained around natural teeth in studies of the same years, Burkhardt's work set the baseline for further research in the field of peri-implant soft-tissue therapy.

Significant investigations into the correction of peri-implant soft-tissue dehiscences occurred in the following decade (2010–2020). Improved techniques were proposed (Roccuzzo et al., 2014), and modifications of prosthetic components were suggested to enhance the coronal tissue phenotype before coverage procedures, aiming to improve predictability of coverage (Zucchelli et al., 2013, 2018, 2019). Additionally, studies were conducted to compare the efficacy of dermal matrices with CTG (Anderson et al., 2014). In the latest research, different techniques are being compared using well-designed randomized clinical trials (Tavelli et al., 2023), and cutting-edge technology is being employed to further enhance our understanding of peri-implant wound healing (Tavelli, Barootchi, Majzoub, et al., 2021).

With the increasing demand for optimal aesthetics, implant retention alone is no longer sufficient for patients. Today, more than ever, peri-implant soft-tissue dehiscences and deficiencies present significant challenges for patients and clinicians (Figure 3). Interestingly, periodontists faced similar challenges 70 years ago when treating mucogingival problems in natural teeth (Figure 4). However, matters are facilitated today by the use of well-tested techniques and materials.

The field of peri-implant soft-tissue defects has become a great arena for research and advancements, encompassing classifications (Barootchi et al., 2022; Zucchelli et al., 2019) and therapy (Tavelli et al., 2023). Encouraging results have been obtained, and there is a need for more extensive literature with top-tier methodology.

7 | CONCLUSIONS

The dynamic history of periodontal plastic surgery illustrates the dedication of clinicians and researchers to overcome clinical challenges through innovative choices, scientific research and increasingly refined surgical techniques. Understanding these pioneers' challenges and thought processes helps us to get a broader view of the current state of the field and highlights opportunities for further improvement. The story of the evolution of periodontal plastic surgery is one of scientific progress and ongoing research, fostering a sense of community and shared knowledge. Each advancement is built upon the last, furthering our understanding and capabilities. While new challenges continue to emerge, they provide opportunities for continued growth and improvement of the field. As we reflect on the history of periodontal plastic surgery, we can gain a deeper appreciation of the contributions by those who came before us and find inspiration to continue the tradition of innovation and advancement in the field.

AUTHOR CONTRIBUTIONS

GiovanPaolo Pini Prato and Riccardo Di Gianfilippo significantly contributed to the ideation, realization and writing of the study, and approved the last version before submission.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonablerequest.

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