in collaboration with Silvano Tramonte

COMPARATIVE HISTOLOGY OF THE NECK AREA OF A NATURAL TOOTH AND THREE TRAMONTE SCREWS

Part III

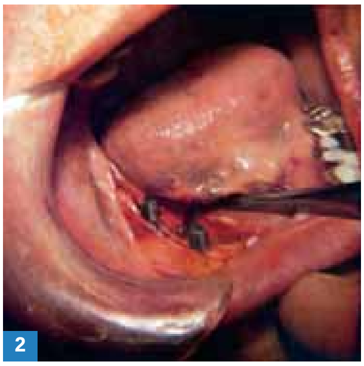
In 1972 Antonio Camera, who at the time was director of the Clinical and Histology and Anatomopathology Research Department of the G. Ronzoni Medical Surgical Institute in Milan, Ugo Pasqualini, who was professor of Maxillofacial Surgery and Prosthodontics at the University of Modena, and Stefano M. Tramonte, inventor and patentee of the drive screw (1–14) and also the first to employ titanium in implant dentistry (15, 16), published a study that is still unique today: the comparative histological study of the tissues forming the epithelial seal at the implant and natural tooth emerging area (17).

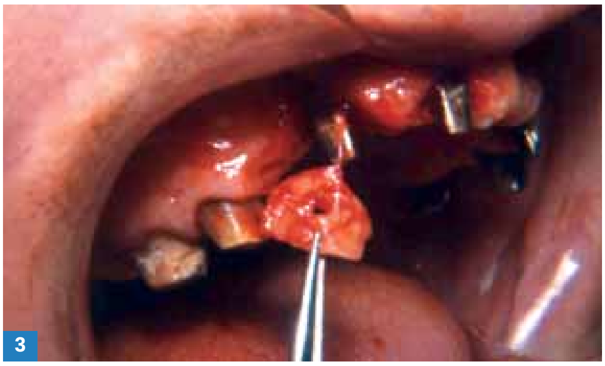
The study, published 36 years ago, addressed all the questions of the era regarding the hazards of hypothetical intra- and extra-tissutal communication and the creation of a surrogate epithelial attachment in place of the natural one. Nevertheless, the research went far beyond this, although it was not given proper recognition at the time. It confirmed—decades in advance—the absolute need for a biological space to assure a completely safe relationship between implant structures and biological tissues, i.e. avoiding peri-implant bone resorption, which is not physiological but must be considered a true iatrogenic outcome.

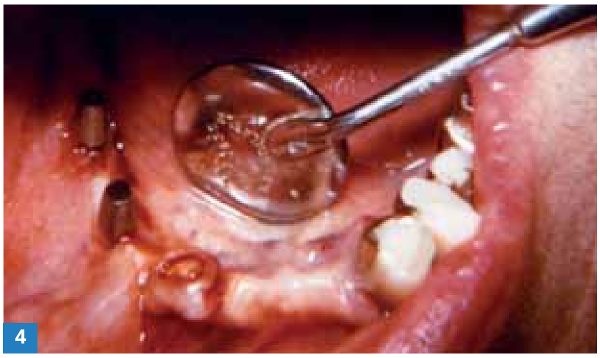
The Tramonte implant was designed in 1959 for the specific purpose of immediate loading. It began to be manufactured in titanium in 1963 and had a biological width area, as a result of which it aroused hostility and misunderstanding within the academic and scientific world. Nevertheless, it anticipated—by decades—the principles that are now are recognized as the most scientifically advanced: immediate loading, flapless insertion, biological width, single-phase execution, advanced design of the endosseous core and better compliance with the theoretically ideal shape, Lemons's plateau (18) from a biomechanical standpoint, and a smaller emerging portion of the implant in order to protect the biological seal (19). In 2005 Camera, working with Marco E. Pasqualini and Silvano Tramonte, reviewed the impressive work published 33 years earlier and conducted a critical analysis. The patient from 1970 required placement of a Linkow blade implant (20) in the lower right distal area, as the site was unfit for a one-step implant due to severe horizontal bone resorption.

Three years earlier, a gold-resin bridge had been placed in the upper arch over three Tramonte self-threading screws and three natural abutments (Fig. 1). Before placement of the blade implant (1970), the bridge was removed in order to check the status of the three upper screw implants, which appeared to be stable and were surrounded by a healthy mucosa. Periodontal probing around the neck of each implant assessed pocket depth (2 to 3 mm) and the onset of classic compression ischemia could be noted. The blade-implant surgery was performed on October 26,

Fig. 1 Preoperative panoramic X-ray.







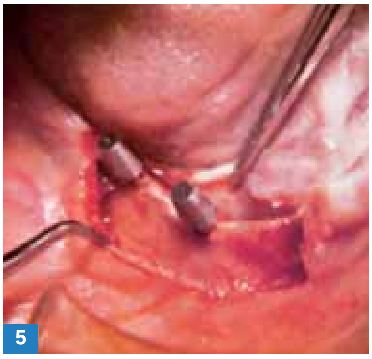


Fig. 2 The blade after the surgery. Note the perfect position of the blade's upper surface, over 2 mm below the cortical bone.

Fig. 3 The biopsy specimen at the neck level of the Tramonte screws.

Fig. 4 Section collected around a patient's tooth affected by periodontitis.

Fig. 5 Explorative visualization of the newly formed bone over the blade's top surface and around the neck of the two abutments 6 months after surgery (1971).

1970 (Fig. 2).

Six months later (1971) the patient returned because the upper bridge had become decemented. During the medical examination, she agreed to undergo a biopsy sampling around the Tramonte screws, which were very stable (Fig. 3), and a lower tooth affected by periodontal disease (Fig. 4). With the patient's consent, the surgical flap incision made for the sampling was extended distally, which made it possible to observe the perfect osseointegration of the blade (Fig. 5). After prosthesis cementation, a comparative histological assessment was performed.

Aim of the research

The researchers' aim in 1971 was to analyze and verify the behavior of the mucosa and the underlying corium at the level of the epithelial attachment surrounding the emergence profile of the Tramonte implant fixture. What we intend to do today—in addition to reproposing a study that is still current and valuable in a field in which few studies have been conducted (21–38)—is to assess the effect of a traditional prosthesis on peri-implant soft tissue (Fig. 6), i.e. a prosthesis that does not emerge from the mucosa like those on buried implants, but is supported by the gum like any prosthetic bridge element on natural abutments, the kind usually employed with this type of implant.

The most common criticism leveled against these kinds of prostheses is that they do not permit proper oral hygiene, with the ensuing risk of perimplantitis. This work also aims to provide information about the epithelial attachment and its different functional interpretations, clarifying its role in the etiopathogenesis of periodontal diseases as a locus minoris resistentiae for hypothetical microbial invasion from the outside. We hypothesize that there is a sectoral frequency for certain severe periodontal lesions, limited to one or a few teeth in direct contact with periodontal areas that are instead healthy or affected to a much lesser extent (39). There is no logical explanation for microbial virulence limited to the gum and periodontal tissues of a single tooth (or group of teeth), while the same bacterial strain, at the same concentration, is clearly harmless a few mil-

Fig. 6 Prosthesis placed at case completion (1971).

limeters from the lesions. This specific research shows that there is no peri-implant pathology around the titanium implant abutments, while the periodontal disease of the soft tissues surrounding the natural abutment is clinically detectable and histologically confirmed.

Materials and Methods

The specimens (Figs. 3, 7) were fixed in 5% formalin, paraffin processed, cut into 4-mm-thick serial sections stained with hematoxylin-eosin (Fig. 8). Each biopsy specimen underwent two identical analyses in order to assess:

- how the mucous epithelium in contact with the emerging portion of the implant recessed and was replaced by corium, and to what extent;
- the extent and differences in morphological behavior that could be found at the epithelial attachment area of the natural tooth and the three Tramonte screws.

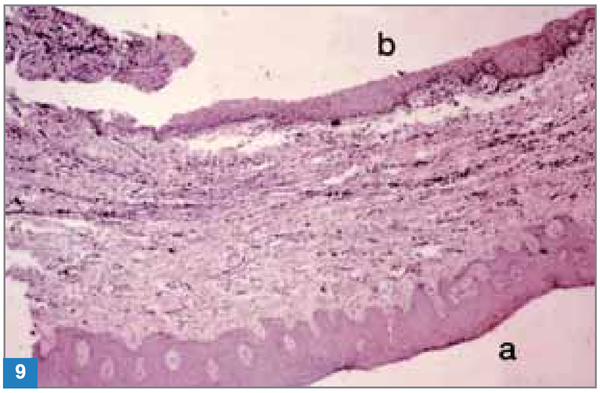
In order to progressively assess the histological pattern of the epithelium and submucous corium at the epithelial attachment, the specimens were divided into two groups, according to the two typical cutting sections: orthogonal and parallel to the axis of the emerging screws and natural tooth. Serial sections, orthogonal and parallel to the mentioned axis, were then harvested, and the area of the epithelial attachment was expected to be found around it.
The images should thus have shown the complete pattern of the histological morphology for both the external and internal mucous tissue in contact with the neck of the screws and the natural tooth. In all, 2400 sections were examined.

Results

All the serial sections of the mucosa attached to the neck of the implants were histologically analogous. The external mucosa was always protected by an adherent keratin layer, below which it was possible to detect the complete sequence of epithelial layers up to the germinal cells of the basal layer, spread along the digitations in the underlying corium. The metal-facing tissue was always devoid of the keratin layer, with progressive loss of the cellular layers up to a single layer of basal cells. Below it there was a perfectly normal corium. A superficial section performed orthogonally to the implant axis, like the ones shown in Figures 9 and 10, clearly shows that the external mucosa, indicated as letter “a”, is protected by a detectable keratin layer, while the internal layer (letter “b”) lacks keratin protection. A slightly deeper section (Fig. 11) shows a thinner kerati-

Fig. 7 The arrows show how, with the progression of the sections, the architecture of the external mucosa (a) will be examined histologically and compared to that of the internal mucosa (b).

Fig. 8 Overview of some of the 2400 histological specimens.



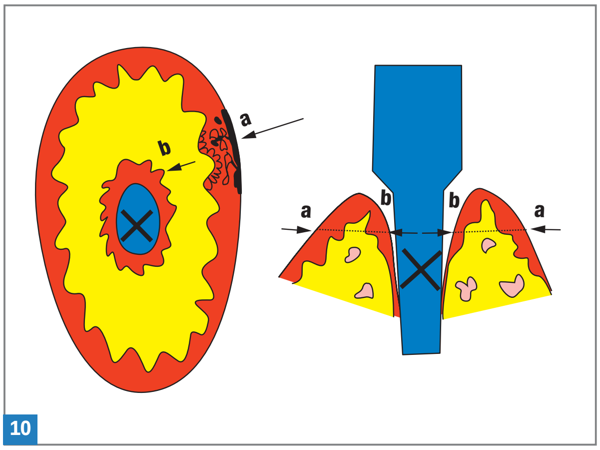
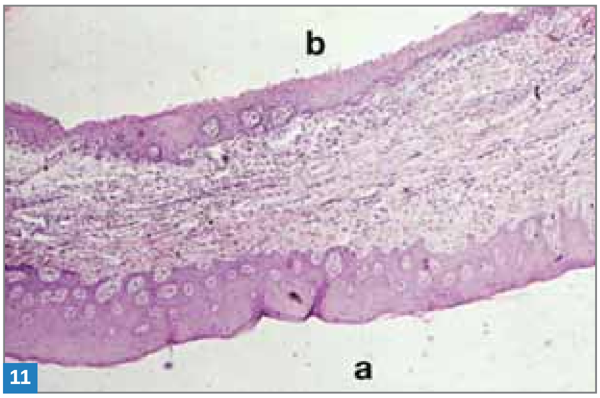


Fig. 10 Original diagram illustrating the macroscopic morphology of the specimen in Figure 3 (left) and showing the progression of the orthogonal sections (right).



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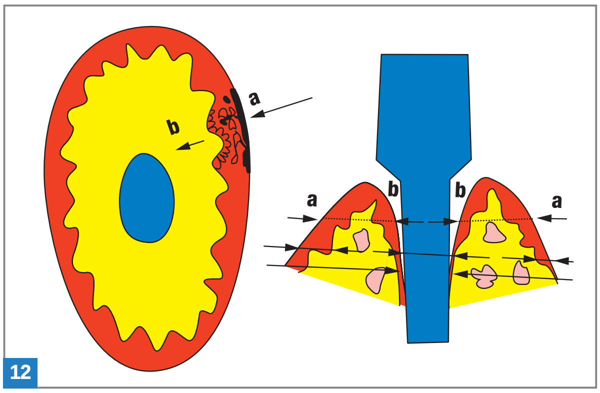

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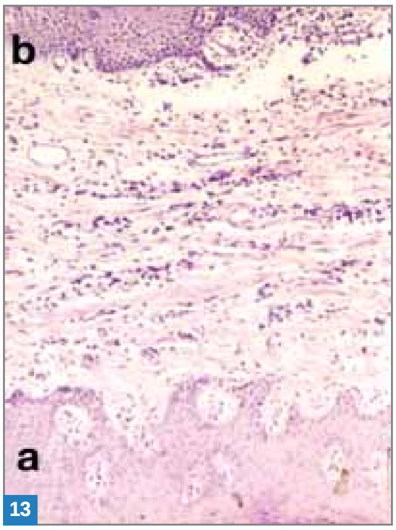
nous layer and all the epithelial layers on the (a) side, while on the (b) side, the mucosa in contact with the implant, the keratin layer is absent, as is the underlying epithelial layer. The different morphology of the corium infiltrations, well-defined and abundant at the base of the external mucosa (a) and almost absent at the base of the internal mucosa (b), can also be observed.
Figure 12 is another diagram representing the progression towards the junction area of the sections. A detail of Figure 11 at a higher magnification (Fig. 13) clearly illustrates the different appearance of the internal and external mucosa.
The diagram (Fig. 14) shows the position of the last sections at the junctional area. Figure 15 also shows the difference between the external mucosa (a), with a keratin layer and all the epithelial layers up to the numerous digitations of the deepest layer, and the residue of the internal mucosa (b) in a regressive state, especially in the area indicated by the arrow.
In Figure 16 the mucosa is reduced to a thin layer of germinal basal cells corresponding to the area indicated by the arrow in the previous figure. An even deeper section (Fig. 17) shows in the external mucosa composed of all layers in (a), while in (b) the internal mucosa has disappeared, replaced by the submucous corium.
In Figure 18, a higher magnification of the previ-



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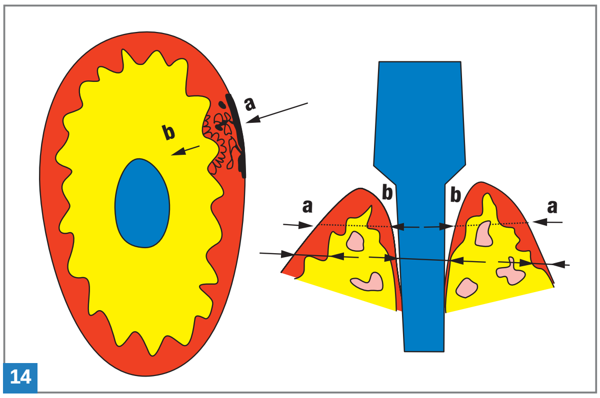

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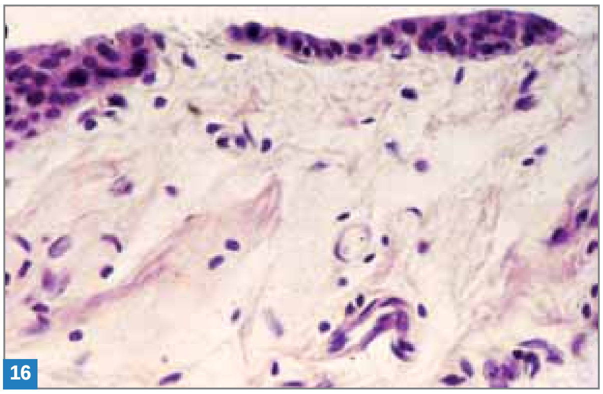
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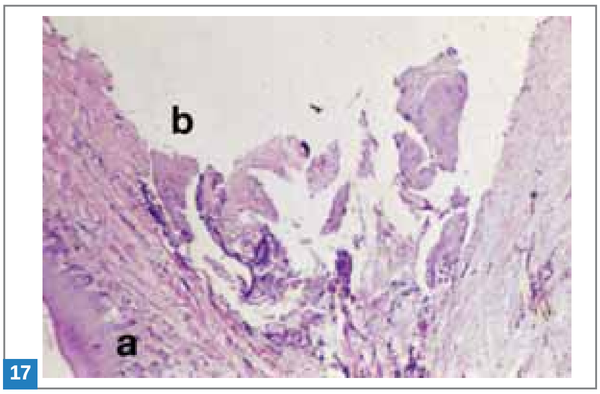
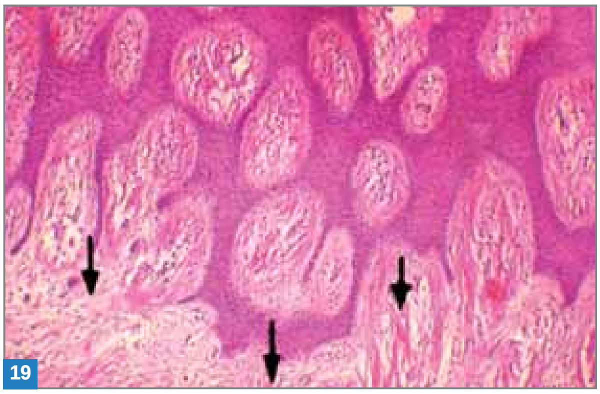


oral cavity represent a very important element of comparison.
The cell morphology of the periodontium adjacent to the neck area of the natural tooth (a lower right premolar with periodontal disease) shows clear signs of inflammation, recession and migration of the epithelial attachment. Both in the serial sections performed along the parallel axis, which shows the pocket profile along the root cement (Fig. 20), and in the orthogonal ones (Fig. 21), one can clearly observe all the signs of chronic inflammation of the epithelium and corium, with the typical increased infiltrations of the basal membrane towards the deepest layers and classic parvicellular infiltration of the tissues.
In a few areas the increased digitation of the epithelial basal layer almost reaches the opposite side, possibly leading to the loss of the overlying tissue due to necrosis (Figs. 22, 23).
The histological pattern of the serial sections performed in the tissues surrounding the emergence of the three Tramonte screws is quite different and constantly normal in appearance. The substantial morphological difference between the external buccal and lingual epithelium and the in-



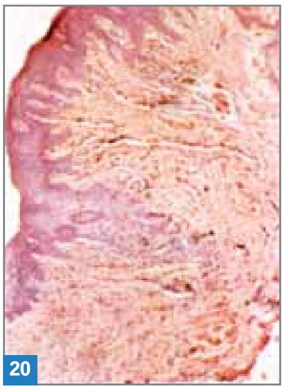


Fig. 20 Serial section performed along the main axis of the root. Evidence of abnormal epithelial digitations, parvicellular invasion and hemorrhagic suffusion due to the inflammatory process (hematoxylin-eosin 180x).

ous figure, (a) clearly shows the complete sequence of epithelial layers and the well-defined digitations in the underlying corium.
Figure 19 illustrates a very different pattern: The mucosa pertaining to the biopsy specimen collected in the area surrounding the tooth affected by periodontitis is inflamed and hypertrophic. The arrows indicate the marked progression of the papillae in the underlying inflamed corium.

Discussion

The substantial number of examined sections and the repetitive pattern of the histological specimens permit exhaustive analysis of the neck area. Moreover, the specimens collected around a natural tooth affected by periodontosis in the same

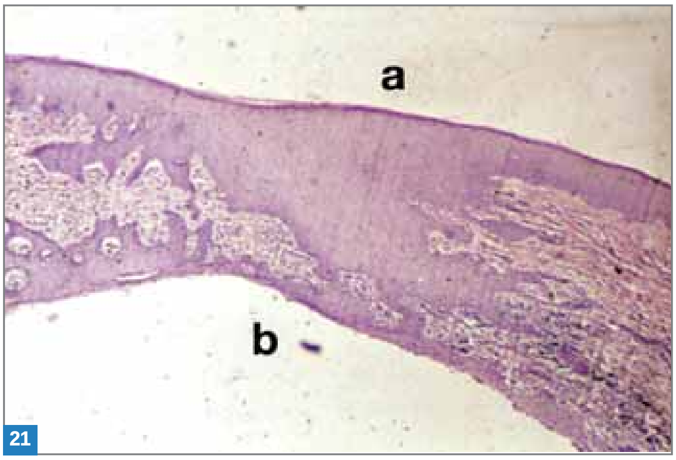


Fig. 21 Orthogonal section around the tooth affected with periodontitis. Clear signs of phlogosis.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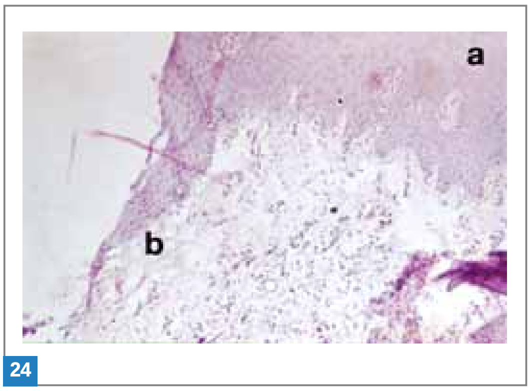
Figs. 22, 23 Clear signs of inflammation of the periodontal tissues of the compromised natural tooth.

ternal epithelium facing the metal can clearly be observed, and it is very well defined. The external epithelium always has the keratinous protective layer and always shows papillary digitations in the corium, reactive to the physiological stimuli due to mastication. Even at a depth of 1–2 mm, the internal epithelium loses the keratinous layer and, moving toward the deepest serial sections, it shows the progressive and regular reduction of the cellular layer up to the corium. What is absolutely remarkable is the constant absence of digitations, a clear sign of higher reactive cell turnover to irritative stimuli. This allows us to state that the tissue arrangement around the abutments of the Tramonte screws, used as support for a traditional prosthesis, represents an absolutely normal pattern and, on an inductive level, allows us to predict that the current state of the seal will be preserved for a long time.

This study made it possible to verify histologically that the morphology of the peri-implant biological seal of these implants is identical to that of the epithelial attachment of natural sound teeth, and the following considerations can be made.

- The three hemisections of all examined specimens, collected in serial sections parallel to the alloplastic posts, always show the normal profile of the internal epithelium with no signs of inflammation or disarray of the cellular morphology. Regarding the study focusing on the biological seal area, it can be stated that the behavior of the cellular layers and the underlying corium is identical to that ascertained by means of analogous studies on natural teeth (Figs. 24–27). Despite the lack of submicroscopic evidence of a specific insertion of the pseudopods of the basal layer cells on the metal surface, further research demonstrated hemidesmosomal adhesion to the titanium surface, which is able to form a true seal that isolates the internal cell spaces and discontinues the spatial communication between the latter and the oral cavity. The permanence and consolidation of such a seal testifies to the absolute biocompatibility of these implants, which do not show signs of tissue degeneration in the area of their emerging portion when loaded with a prosthesis elevated above the peri-implant tissues.
- The three other hemisections, sectioned orthogonally to the main axis of the alloplastic posts, show similar behavior, varying only in the morphological appearance corresponding to the different examined areas (Figs. 9, 11, 13, 15–17).



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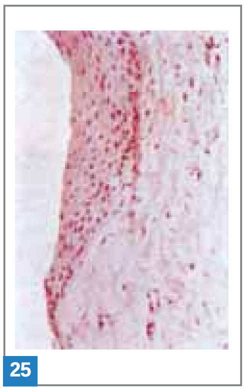
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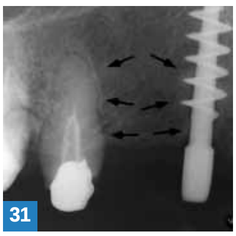
Fig. 24 Cytomorphology of the periodontal tissue around the neck of the implant. The layers of the internal mucosa are progressively thinner (a), becoming single-layer. A perfectly normal corium can be observed below it. Note the absence of epithelial digitations. Healthy external mucosa (b) (hematoxylin-eosin 120x).
Fig. 25 Detail at a higher magnification. Note the even reduction of the internal epithelium layers going from the surface to the epithelial attachment area (hematoxylin-eosin 240x). **Fig. 26** The previous figure at a higher magnification (400x).
Fig. 27 Detail of the epithelial attachment (400x). The sole presence of the basal cells is evident.

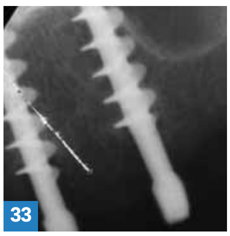
Thirteen-year follow-up

The patient was reexamined 13 years after the first implant surgery (1980) for a checkup and to assess the implants' osseointegration 10 years after the bioptic specimens were taken. Figures 28 and 29 respectively show the photograph and the orthopantomography taken at the time. Notably, 13 years after the procedure tissue recession is more severe on the natural teeth than around the screws and the blade. The oral hygiene of the 81-year-old patient had deteriorated by this time, but the peri-implant mucosa nevertheless appears to be in good health, whereas around the natural teeth (second lower incisor) the tissue is edematous and has reddened margins, the classic sign of inflammation. The root has plaque deposits, which are absent on the implant abutments.
Furthermore, gingival recession can be noted only around the implants whose emergence is markedly buccalized, and it is thus a consequence of this particular condition. With the advent of abutment translation, achieved by bending the emerging necks and through better repositioning of the abutments with respect to the crest, this problem—which, as we can see, did not affect the success of the implant—was solved.
The OPG shown in Figure 29 reveals that, in the meantime, the upper left molar was lost and the second left premolar was replaced with an implant. The prosthesis was naturally shortened and adjusted in relation to the new oral conditions (Fig. 30). The intraoral radiographies (Figs. 31–33) make it possible to verify the perfect osseointegration of the four screws, surrounded by a layer of apposed compact bone. In particular, Figure 33 shows that the use of a long-neck implant permits more adequate positioning of the coronal spiral and the abutment, in addition to better observance of the biological width, while avoiding the small bone-resorption cones that can be noted around the other three screws. In any event, it is important to consider the patient's age, sex and the limited number of implants in relation to bone quality, which gradually deteriorated from the time of the first implant rehabilitation. This also allows us to reassert that during the surgical planning phase it is essential to consider not only the patient's current condition, but also normal and predictable future conditions, given the implant's proven ability to stay in place for decades.
The clinical appearance of the mucosae where the implant abutments emerged was also excellent (Fig. 34). With the patient's consent, surgical inspection of the upper right canine was performed

Fig. 30 The image shows the changes made to the prosthesis following extraction of the left first molar and second premolar: relining of the second upper premolar for insertion of the implant abutment, filing of the molar and filling of the residual cavity. It is interesting to note that with using a smaller implant emergence makes it easier to find the best implant site.

by incision and flap detachment to expose the external surface of the including compact bone (Fig. 35). This image from many years ago reveals several interesting details: the buccal depression filled with blood visible in the apical area between the two implants—barely noticeable in the X-ray and not treatable with the modern reconstructive techniques of the time—greatly influenced the implant insertions. The implant's coronal thread is dehiscent due to severe horizontal resorption, but the surrounding bone is nevertheless compact and completely normal. Lastly, excessive deepening of the abutment in the mucosa, bringing it closer to the crestal bone, led to resorption reactions that were absent around the implant of the upper left second premolar, which was inserted more correctly. This should persuade all those applying this system to follow modern protocols and use short- and long-neck implants skillfully.
In any event, a periodontal probe forced into the



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junctional area was unable to penetrate it (Fig. 36), also demonstrating the diagnostic limitations of intraoral radiographic images.

Conclusions

This study, performed on a 72-year-old patient (1971) with three Tramonte screws loaded four years earlier, remains one of the most comprehensive histological and anatomopathological examinations (with optical microscopy) ever performed on the junctional area of endosseous emerging immediate-load implants. This research made it possible to ascertain:

- perfect healing of the bone tissue with no bone loss around the neck of the three immediate-load Tramonte implants after four (1967–71) and thirteen (1967–80) years of service (40, 45);
- the constant absence of clinical signs of inflammation of the tissues adjacent to the emerging area of the implants;
- the morphological behavior of the tissues adjacent to the Tramonte implant emergences, identical to the histological behavior of the periodontium in contact with the neck area of natural teeth, at the resolution limit of optical microscopes;
- the degenerative patterns, in the same patient, of a natural tooth with clinical and histological signs of periodontal inflammation and chronic recession of the epithelial attachment, without damaging the excellent clinical and histological status of the implants;
- the absolute tolerability of a traditional prosthesis, which did not cause any kind of problem with the implants after 13 years of service in a mouth where conditions had deteriorated, due both to the normal loss of tissue trophism caused by aging and the progressive decline of oral hygiene often observed among the elderly (46, 47).


36

Furthermore, we believe that it is safe to state that the theoretical assumptions underlying the design of this implant (which must be acknowledged as the first implant specifically designed for immediate loading, the first with a biological width area at a time when this definition did not even exist and, lastly, the first to use titanium in implant dentistry) proved to be valid based on outcome as well as additional studies and research (49). In a recent experimental clinical trial, over a period of about four years (1998–2001) a total of 181 implants were inserted (158 Tramonte screws and 23 implants with narrow threading and fitted with a prosthetic connection): 103 implants were inserted in the upper arch (57.2%), and 78 in the lower arch (42.8%) (49). At the end of the follow-up period, 96% of the placed implants proved to be successful. Failures were ascribable to splinting problems and implant solidarization, i.e. to fracture of the temporary prosthesis. Considering the two different types of implant, the wide-thread implant showed a success rate of 97.5%, whereas the success rate for the narrow-thread type was 87%.

This concluded the study, which spanned nearly 40 years, going from Tramonte's implant placement (1967) a few years after the introduction of titanium in implant dentistry (1963–64) to the first extensive histological research on the peri-implant biological seal in humans (1972), and on to a recent university study (2002) endorsing the design characteristics of the endosseous portion of this implant as the most suitable for immediate loading. This also concurs with the theoretical studies conducted by Lemons on the biomechanics of implant morphology and by James on the most appropriate implant emergence size in order to avoid peri-implant resorption.

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