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RESEARCH

Influence of crestal and sub-crestal implant position on development of peri-implant diseases: a 5-year retrospective analysis

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Abstract

Objectives The aim of the present study was to evaluate the influence of crestal and subcrestal implant position on development of peri-implant diseases.

Materials and methods The study was designed as a retrospective clinical and radiographic analysis. Implant-supported fixed dental prostheses were allocated in two groups: with the shoulder (i) placed in sub-crestal level and (ii) placed at bone level. For each patient, the following clinical variables were assessed: FMPS, FMBS, PII, BOP, and PD. After prothesis delivery, an intraoral radiograph was obtained; this exam was performed also at 5 years of observation period.

Results No statistically significant difference was found in terms of FMPS and FMBS at baseline and after 5 years follow-up ($P < 0.05$). A statistically significant difference was assessed between PD of control group and test group ($P = 0.042$). Patient-based analysis showed a 25.6% of peri-implant mucositis and 32.6% of peri-implantitis for implants placed with the shoulder in crestal position, while for implants inserted in sub-crestal position the percentage of peri-implant-mucositis and peri-implantitis were 19%; no statistically significant difference was found between groups after 5 years ($P < 0.05$).

Conclusions Within the limitation of the present study, the clinical and radiographic outcomes showed that the percentage of peri-implant mucositis and peri-implantitis was not statistically significant for both groups after 5 years follow-up.

Clinical relevance The outcomes of present study clinically demonstrated that a deep position of implant shoulder did not provide any benefits. On the contrary, it may be considered a possible risk indicator for implant diseases.

Keywords Periodontitis · Smoke · Peri-implant mucositis · Peri-implantitis · Peri-implant bone loss

Introduction

The implantology is a highly successful treatment option for totally and partially edentulous patients, and nowadays, it has become a routine procedure in clinical practice [1]. Although long-term studies reported high survival and success rate, after implant osseointegration healing, biological complications and inflammatory conditions of the soft tissue and of the bone surrounding implants can occur [2]. The etiology and pathogenesis of peri-implant disease received increasing attention, and many key factors associated with the development of this clinical conditions were identified [3]. In the last decade, there was the need to define and differentiate the peri-implant disease from a state of peri-implant health. At the 2017 World Workshop on Peri-implant Diseases and Conditions, the peri-implant disease was considered a collective term for inflammatory process in the tissues surrounding an implant [4]. At the same Word Workshop, peri-implant mucositis was defined

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as an inflammatory lesion in soft tissues surrounding an endosseous implant in the absence of loss of supporting bone or continuing marginal bone loss. On the contrary, the peri-implantitis is characterized by irreversible progressive loss of supporting bone [4]. Inappropriate patient selection and inadequate periodontal therapy, lack of diagnosis and management of peri-implant mucositis, wrong implant placement, poor postoperative care, and not well-designed prosthetic reconstruction were proposed by the literature as factors that may lead to peri-implantitis [5–16]. Many studies identified potential risk variables associated to peri-implant diseases such as the periodontitis, smoking, diabetes, poor plaque control, and no adherence to supportive periodontal therapy [17–22]. These trials evidenced that development of peri-implant disease was correlated not only to microbiological factors, but also to other aspects of the implant therapy such as the cleanability and fit of the implant-supported prosthesis [19–25]. The implant design and the position of implant shoulder could be considered a risk factor for the development of peri-implant diseases. A recent study reported that no statistically significant difference was found in terms of peri-implant inflammation resolution at bone level and tissue level implants [26]. However, there are a paucity of evidences about the implant shoulder position (i.e., bone level or sub-crestal position) on the development of peri-implant mucositis and peri-implantitis.

The aim of the present study was to evaluate the influence of crestal and subcrestal implant position on development of peri-implant diseases.

Materials and methods

Study design

The study was designed as a retrospective clinical and radiographic analysis.

Implant-supported fixed dental prostheses recruited in the present investigation were allocated in two groups: implants with the shoulder placed in sub-crestal level (test group) and implants placed at bone level (control group).

The subjects were enrolled from patient pool of the Department of Oral Surgery of the University "Federico II" of Naples, Italy.

The clinical and radiographic data from a public database of patients receiving a dental implant (Kontact Implant, Biotech Dental, Salon-de-Provence, France) between January 2017 and December 2017 were screened. The follow-up was 5 years (December 2022). The study was conducted in observance to the Principles of the Declaration of Helsinki on experimentation involving human subjects. All patients signed a written consent. Statistically significant different between implants placed at bone level and at sub-crestal position was considered null hypothesis.

Eligibility criteria

To be included in the research, the following criteria had to be fulfilled:

- Age > 18 years
- Male or female
- Patients treated by mean of one or more osseointegrated implants
- Healthy patients and patients with past history of periodontitis (absence of PD ≥ 5 mm) [27]
- No-smokers and smokers (no more than 10 cigarettes/day)
- Patients in regular supportive periodontal therapy (SPT) program
- Implants placed in healed bone (type 4 implant placement according to Hammerle) [28]
- Screw-retained crown

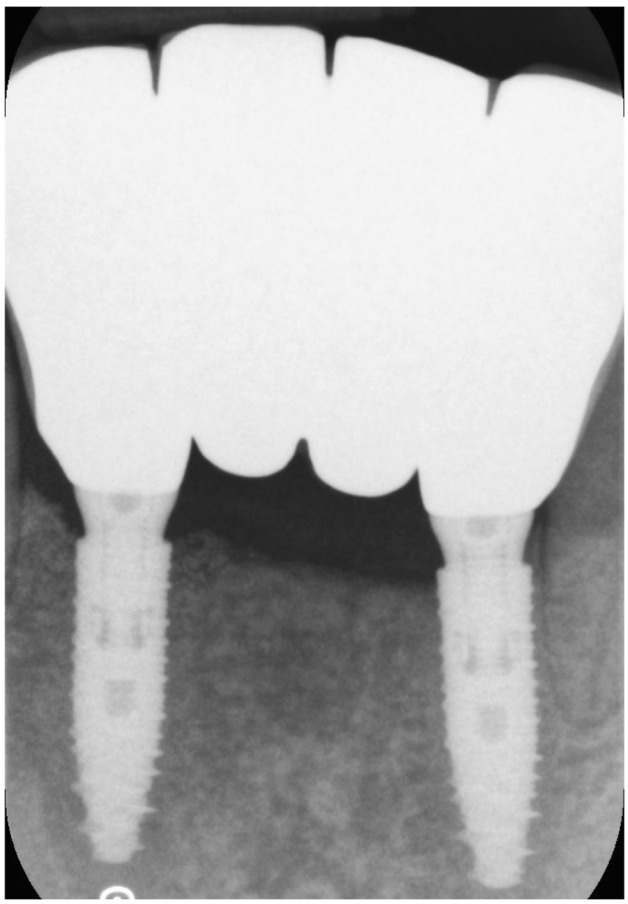

Fig. 1 Intraoral radiograph after prothesis on sub-crestal implants delivery

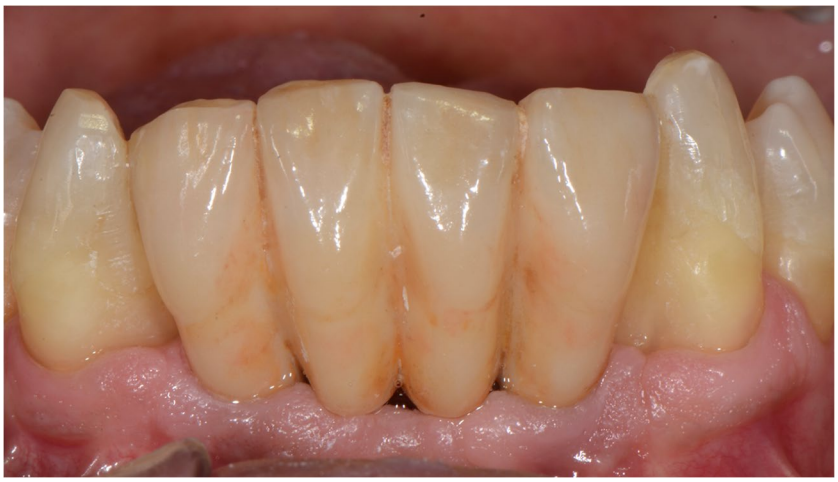

Fig. 2 Final rehabilitation on test group

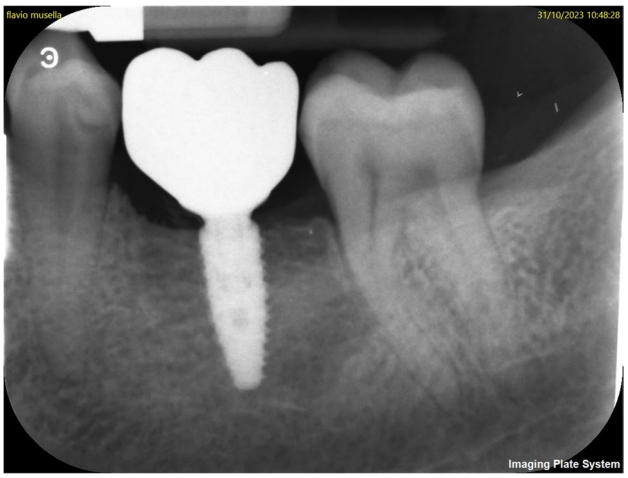

Fig. 3 Intraoral radiograph after prosthesis on crestal implant delivery

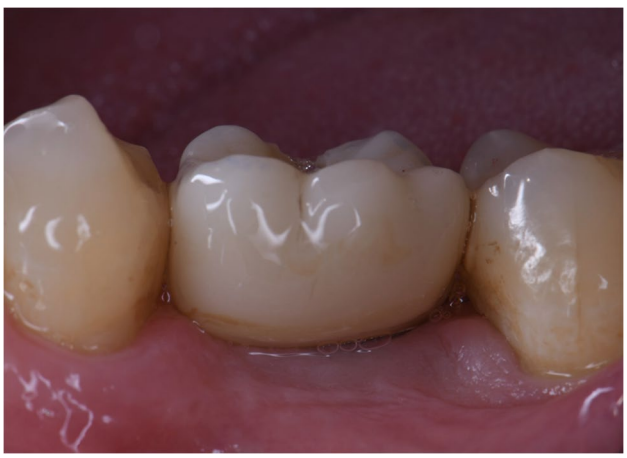

Fig. 4 Final rehabilitation on control group

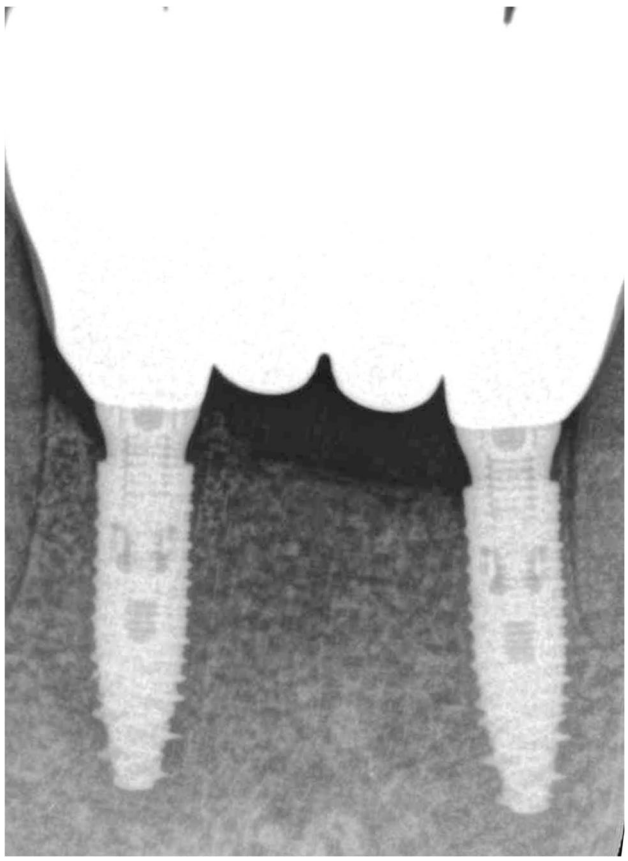

Fig. 5 Radiographic exam at follow-up of the sub-crestal implants

- Loading performed after 3 or 6 months after implant placement
- Availability of a periodontal chart and periapical radiograph obtained using the parallel long cone technique at

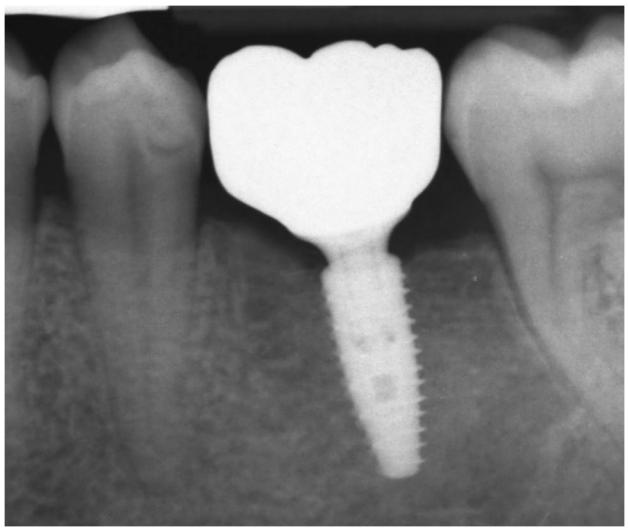

Fig. 6 Radiographic exam at follow-up of the crestal implant

the time of the crown insertion and at the 5 years follow-up period

Patients were excluded on the basis of the following:

- Medical condition contraindicating surgical intervention
- Pregnancy
- Full-mouth plaque score (FMPS) and full-mouth bleeding score (FMBS) > 25%
- Unloaded implants
- Implant-supported overdentures or Toronto-Branemark bridge
- Cemented crown restoration
- Lack of previous radiographic and clinical documentation
- Untreated periodontitis or erratic compliance with the SPT program

Outcome measures

For each patient, the following clinical variables were assessed:

- Full-mouth plaque score (FMPS) and full-mouth bleeding score (FMBS) representing the percentage of sites covered with plaque and with bleeding on probing in the entire dentition [29]
- Presence of plaque at implant sites according to plaque index (PlI)
- Presence of bleeding on probing (BOP) at implant sites
- Pocket probing depth (PD) measured from the peri-implant mucosal margin to the bottom of the sulcus

All peri-implant parameters were assessed at six sites (i.e., mesio-buccal, buccal, disto-buccal, disto-oral, oral, and mesio-oral) using a manual periodontal probe (PerioWise color coded probe, Premier, Plymouth Meeting, PA, USA) with a probing force of approximately 0.2 N. The percentage of implants with peri-implant mucositis and peri-implantitis was also recorded and considered as primary outcomes. The diagnosis of peri-implant mucositis and peri-implantitis was found according to the 2017 World Workshop on Peri-implant Diseases and Conditions [4]. Briefly, the following parameters were accepted for the diagnosis of peri-implant mucositis: swelling, erythema, presence of bleeding on probing and or suppuration, absence of bone loss ≤ 2 mm. The diagnosis of peri-implantitis requires all signs of peri-implant mucositis in combination with PD ≥ 6 mm and a radiographic bone loss > 2 mm.

Radiographic examination

After prothesis delivery, an intraoral radiograph was obtained using the parallel long cone; this exam was performed also at 5 years of observation period. The location of the marginal bone levels in relation to the implant shoulder was assessed at the mesial and the distal aspect using a software program (VixWin Platinum Imaging Software; Gendex, Des Plaines, IL, USA). The digitized images were scaled to the known distance between the implant threads 0.7 mm. The radiographic marginal bone loss (BL) was calculated by subtracting the marginal bone level at baseline

Table 2 Implant location

	Max		Mdb	
	Ant	Post	Ant	Post
Controls ($n=43$)	0	11	2	30
Cases ($n=63$)	8	33	3	19
Sign	0.030			

Table 1 Demographic characteristics

	Age (mean ± std dev)	Gender (M/F, *n*; %)	Perio (Y/N, *n*; %)	Smoking (Y/N, *n*; %)
Controls ($n=21$)	51.99 ± 8.02	10/11, 47.7/52.4	15/6, 71.4/28.6	12/9, 57.1/42.9
Cases ($n=27$)	47.11 ± 9.28	9/18, 33.3/66.7	16/11. 59.3/40.7	8/19, 29.6/70.4
Sign	0.06	0.380	0.544	0.079

Table 3 Clinical Dates (patient based)

	FMPS baseline (mean ± std dev)	FMBS baseline (mean ± std dev)	FMPS follow-up (mean ± std dev)	FMBS follow-up (mean ± std dev)
Controls ($n=21$)	16.6 ± 4.8	11.1 ± 4.6	18.0 ± 4.8	13.4 ± 5.0
Cases ($n=27$)	17.6 ± 5.3	12.0 ± 5.6	17.7 ± 5.1	11.7 ± 5.0
Sign	0.497	0.673	0.884	0.239

from marginal bone level to abutment connections at the 5 years follow-up.

Clinical procedure

Before the implant therapy, all periodontally no-compromised patients were submitted to a professional mechanical plaque removal (PMPR) which included the professional interventions aimed at removing supragingival plaque and calculus [30]. On the contrary, the periodontally compromised patients were submitted to the professional procedure which consisted of supra and sub-gingival instrumentation (steps 1 and 2) using local anesthesia if necessary. After 3 months, periodontal surgery was performed if indicated (pocket depths (PD) ≥ 5 mm, BOP +). All implant surgeries were performed by the same clinician (P.G.). All the implants included in the present study were placed following the classic two-stage protocol according to the manufacturer's instructions. The implant placement at the bone level or subcrestally was randomly decided in preoperative phase by toss of a coin. Surgery was performed under local anesthesia (Mepivacaina 20 mg/ml, with adrenaline, 1:100,000). Implants were placed both in upper and lower jaw, either with the shoulder portion at the level of the bone crest or in sub-crestal position (i.e., 1 mm below the bone crest level). Patients were prescribed an analgesic (Diclofenac, DOC Generici S.r.l., Milano, Italy, 100 mg) immediately after the surgery and after 12 h. A chlorhexidine-digluconate solution 0.12% rinse (twice daily for 1 min) was also prescribed. The sutures were removed after 7 days. The insertion of provisional crown was performed 3/6 months after the surgical time in the mandibular and in the upper maxilla implants. The definitive screw-retained crown was performed 30 days after the temporary restorations and a radiographic exam was performed; final prosthetic restorations was performed by means single crowns or fixed dental prosthesis (FDPs) (Figs. 1, 2, 3, 4).

A radiographic exam was performed also at 5 years of observation period (Figs. 5, 6).

Statistical analysis

The two groups were compared based on the distribution of the following clinical variables detected both at baseline and at follow-up: FMPS, FMBS, PD, REC, presence of plaque (VPI), and bleeding on probing (BOP) as well as radiographically bone loss between baseline and follow-up (bone loss). Because some patients received more than one implant, for each patient only the mean value of PD, REC, bone loss, and the percentage of sites with VPI and BOP were reported in order to reduce the bias risks (patient analysis based). After assessing the normality of the distribution, Student's *t*-test was selected.

An additional implant-based analysis was performed to evaluate if there were differences in implant placement sites and in the prevalence of implants with mucositis, peri-implantitis, and bone loss at follow-up, using the chi-square test.

Results

A total of 48 patients treated with 106 dental implants were selected for the study. All the implants, made of titanium grade 5, had a conic shape characterized by a single thread with sandblasted acid etched surface (Biotech Dental, Salon-de-Provence, France).

Table 1 shows the characteristics of the patient population. In the control group, 21 patients (10 males and 11 females with a mean age of 51.99 ± 8.02) were enrolled. Fifteen subjects were periodontally compromised patients and the 57.1% were smokers. In the test group, 27 patients (9 males and 18 females with a mean age of 47.11 ± 9.28) were recruited. Sixteen patients suffering from a periodontitis and 29.5% were smokers. No statistically significant difference was found between groups ($P<0.05$) (Table 1). The implant location is summarized in Table 2. The majority part of the implants was inserted the posterior area of the mandible and maxilla. Statistically significant difference was found in terms of implant location ($P=0.030$) (Table 2). Likewise, no statistically significant difference was found in terms of FMPS and FMBS at baseline and after 5 years follow-up ($P<0.05$). These clinical parameters were stable during the observation time (Table 3). An increase of PD and GR between baseline and the 5 years follow-up, but no statistically significant differences were observed ($P<0.05$). A statistically significant difference was assessed between PD of control group and test group at 5 years observation time. The PD changed from 4.8 ± 1.3 mm to 4.0 ± 0.9 mm ($P=0.042$) (Table 4). Table 5 reports the mean marginal bone loss at

Table 4 Clinical dates (patient based)

	Baseline				Follow-up				Sign			
	PD (mean ± std dev)	REC (mean ± std dev)	%Plaque (mean ± std dev)	%BOP + (mean ± std dev)	PD (mean ± std dev)	REC (mean ± std dev)	%Plaque (mean ± std dev)	%BOP + (mean ± std dev)	PD	REC	%Plaque	%BOP
Controls ($n=21$)	3.6 ± 0.8	0.0 ± 0	52.0 ± 39.4	0.0 ± 0	4.8 ± 1.3	0.4 ± 0.4	70.6 ± 38.3	31.9 ± 42.3	0.001	0.001	0.093	0.003
Cases ($n=27$)	3.3 ± 0.9	0.0 ± 0	43.1 ± 43.1	0.0 ± 0	4.0 ± 0.9	0.5 ± 0.5	71.5 ± 40.0	40.5 ± 46.4	0.002	0.001	0.019	0.001
Sign	0.487		0.222		0.042	0.133	0.870	0.246				

Table 5 Bone loss

	Bone loss (mean ± std dev)
Controls ($n=21$)	0.90 ± 1.60
Cases ($n=27$)	0.58 ± 0.82
Sign	0.369

5 years observation time. The implant of test group showed a bone loss of 0.58 ± 0.82 mm, while in the control group the mean bone loss was 0.90 ± 1.60 mm. No statistically significant difference was recorded ($P=0.369$) (Table 5). In Table 6 are reported the number and percentage of implants with peri-implant mucositis and peri-implantitis. Patient-based analysis showed a 25.6% of peri-implant mucositis and 32.6% of peri-implantitis for implants placed with the shoulder in crestal position, while for implants inserted in sub-crestal position the percentage of peri-implant-mucositis and peri-implantitis were 19%. Non-statistically significant difference was found between groups after 5-years observation time ($P<0.05$). On the contrary, statistically significant difference were observed for the overall analysis ($P=0.042$).

Discussion

The purpose of the present study was to investigate retrospectively the effect of implant shoulder position (i.e., crestal vs sub-crestal) on the incidence of peri-implant disease (e.g., peri-implant mucositis and peri-implantitis). The outcomes of this study demonstrated that no statistically significant differences were recorded in terms of peri-implant mucositis and peri-implantitis between test and control groups. For these reasons, the null hypothesis for the primary outcome was reject. These results agree to those of previous study proposed by Costa and co-workers showing that the incidence of peri-implantitis was 18% after 5 years follow-up [2]. However, the authors did not report the characteristics of implants used and the position of the shoulder with respect to the alveolar crest. Anyway, the high level of oral hygiene and the adherence to an adequate SPT program seem to play an important role in the maintenance of peri-implant health. In the present investigation, the percentage of peri-implant mucositis was 25.6% and 19% for test and control group respectively, and no significant difference were noted. These findings are corroborated by a study of Hammerle and co-workers that reported the same results in terms of peri-implant inflammation for implants placed at crestal and sub-crestal level [31]. The mean of marginal bone loss was 0.58 ± 0.82 mm for test implants. The same result was found by Flores-Guillen in 5 years randomized controlled clinical trial, where the mean of marginal bone loss of 0.59 mm for implant placed in sub-crestal position [32].

Table 6 Clinical dates (implants based)

	Mucositis (Y/N, *n*; %)	Peri-implantitis (Y/N, *n*; %)	Bone loss score (Y/N, *n*; %)	Overall (Y/N, *n*; %)
Controls ($n=43$)	11/31, 25.6/74.4	14/29, 32.6/67.4	15/28, 34.9/65.1	25/18
Cases ($n=63$)	12/51, 19.0/81.0	12/51, 19.0/81.0	21/42, 33.3/66.7	24/39
Sign	0.476	0.167	0.999	0.042

According to previous studies, this research also evidenced the lack of correlation between the complexity of prosthetic restoration (crown vs bridge) and the peri-implant disease [24, 33, 34]. Only a design and contour of the prosthetic rehabilitation not easily cleanable and the poor marginal fit were suggested as potential predisposing factors to peri-implant disease [35–37]. However, data from a recent critical review suggest that limited evidence indicates the involvement of not well-designed prostheses reconstruction in the manifestation of peri-implant mucositis/peri-implantitis [38]. In the present study a wide range of sub-crestal implant placement (about 1 mm) was selected to achieve primary stability. Ideally, we should have evaluated the impact of each implant depth on bone loss, although due to the small number of patients it was not possible. Further limitations of this study are related to lack of information about preoperative bone morphology (e.g., bone width) and to a significant difference in implant locations between crestal and sub-crestal implants, likely related to a reduced numerosity of study population. Another limitation of the study was the presence of implants supported single crowns and FDPs. In fact, the accessibility to biofilm removal is a crucial point in the development of peri-implant diseases and single unit crown offers a better access for biofilm control with respect to implant-supported dental prosthesis [39]. In the present study, due to the paucity of the sample, a correlation between risk factors and incidence of peri-implant disease was not done. Further studies based on the logistic regression model are needed to verify this aspect.

Conclusion

Within the limitation of this study, the clinical and radiographic outcomes showed that the performance of implants placed with shoulder in crestal or sub-crestal position was the same. After 5 years observation time, the percentage of peri-implant mucositis and peri-implantitis was not statistically significant for both groups. Further trials are needed to confirm the findings of this retrospective analysis.

Author contribution All authors made substantial contribution to the manuscript. G.P. conceived the study and design it; M.T. performed the interpretation of the data; A.M. performed the literature search; G.S performed the searches; G.M. wrote the main manuscript. All authors reviewed the final submitted version.

Declarations

Ethics approval and consent to participate A written informed consent was obtained from all study participants. All procedures performed in this study were in accordance with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Competing interests The authors declare no competing interests.

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