

Periimplant soft-tissue and bone levels around dental implants with different neck designs and neck surface treatments: A retrospective cohort study with 3-year follow-up

Abstract

Objective

The objective of the study was to assess the influence of the implant neck designs and neck surface treatments on periimplant tissue health and radiographic bone loss after 3 years of functional loading of implants with the same body and prosthetic connection.

Materials and methods

A retrospective cohort study was carried out in the Oral Surgery and Implantology Unit of the University of Valencia, Valencia, Spain. Patients treated with implants presenting a neck design without microthreads and a 1.5 mm machined surface and implants with a 0.7 mm machined surface and microthreads with a rough surface with a minimum of 3 years of follow-up were included. Probing pocket depth, bleeding on probing, presence of mucositis and width of keratinized mucosa were assessed 3 years after prosthesis placement. Marginal bone loss was measured in intraoral radiographs by calculating the difference between the measurements at the prosthesis placement and 3 years after loading.

Results

The final sample consisted of 27 partially edentulous patients with a total of 51 dental implants. No significant differences were observed on evaluating probing pocket depth ($P = 0.195$), bleeding on probing ($P = 0.524$), presence of mucositis ($P = 0.916$), width of keratinized mucosa ($P = 0.435$) and marginal bone loss ($P = 0.217$) between both groups.

Conclusion

Within the limitations of the present investigation, implant neck designs and neck surface treatments were not significantly related to periimplant tissue health and radiographic bone loss after 3 years of follow-up.

Keywords

Periimplant hard tissue, periimplant soft tissue, radiology, CT imaging, clinical research, clinical trials.

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Introduction

Bone loss after implant integration and through time of function usually begins at the neck and spreads to the first thread of the body or to the first contact between the bone and the rough surface of the implant,¹ and can be divided into 2 different phases depending on the time of occurrence.^{2–5} The first, early bone loss, is related to re-entry surgery after the healing time or prosthetic connection,⁶ and the second, late bone loss, emerges during the time of implant and prosthesis function.^{4,7,8} Criteria for evaluation of implant success are generally based on clinical and radiological aspects, such as probing depth, implant mobility and periimplant bone changes.⁹ It has been reported that the criteria for successful implant therapy include a median marginal bone loss of <1–1.5 mm during the first year, followed by an annual rate of vertical bone loss of ≤ 0.2 mm.¹⁰

In the last few decades, it has been suggested that marginal bone loss is dependent on several factors, such as the implant neck surface design^{1,4,11–13} and characteristics.^{14,15} It has been proposed that bone retention elements such as microthreads and a rough surface at the implant neck might help stabilize the marginal bone.^{1,12,16,17} Although the conventional smooth implant neck allows the least accumulation of plaque,^{18,19} several studies have evaluated marginal bone loss according to the implant neck involved—machined implant necks and rough necks with microthreads—and have shown more marginal bone loss around these implants compared with implants with a rough surface topography at the implant neck.^{4,12,13,20} The relatively smooth, machined coronal portion is designed to end slightly above the gingival margin of the periimplant soft tissue, thus making the microgap or interface between implant and restoration easily accessible for oral hygiene and resulting in a supragingival location of the crown margin.²¹ Lang et al. in a consensus report concluded that prospective controlled studies on the effects of different implant designs and surfaces had demonstrated that marginal bone levels were generally well preserved after installation of the dental prosthesis (at least for fixed restorations) on a variety of implant types (cumulative bone loss: < 0.5 mm after 3 years).¹¹ However, these studies had a 1-year follow-up and there are no clinical studies comparing the long-term influence of different designs and

surface treatments of implant necks on periimplant tissue. The purpose of this study was to assess the effect of the implant neck designs and neck surface treatments on periimplant tissue health and radiographic bone loss after 3 years of functional loading of implants with the same body and prosthetic connection but different neck designs.

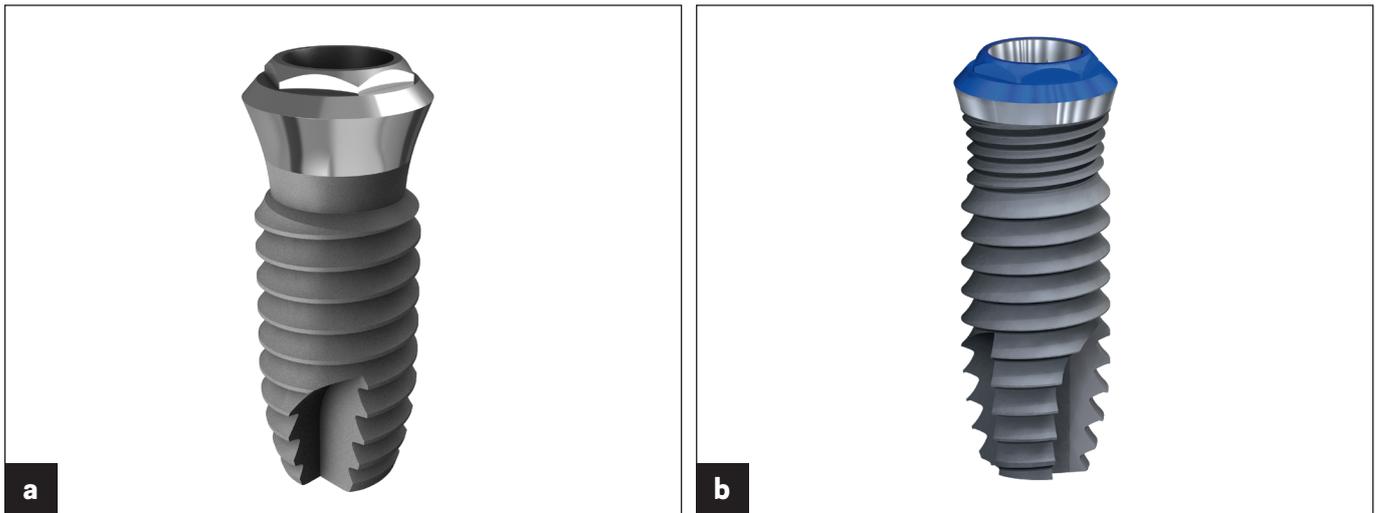
Materials and methods

Study design and sample

A retrospective cohort study was carried out in the Oral Surgery and Implantology Unit of the University of Valencia, Valencia, Spain, between September 2015 and December 2016. This study complied with the ethical principles for medical research involving human subjects established in the Declaration of Helsinki of 1975, as revised in 2013, of the World Medical Assembly. All of the patients received information about the study and were asked to sign a written informed consent form before taking part. The study design was approved by the ethics board of the University of Valencia (approval number: H1467620442582).

Patients who had received single or partial prosthetic rehabilitations on TSA or TSA Advance implants (Phibo, Barcelona, Spain), had a minimum of 3 years of follow-up and who agreed to participate in the study and signed an informed consent were included. Patients who had undergone bone grafting procedures (block bone grafts or guided bone regeneration), had immediate post-extraction implants, had systemic diseases, were undergoing drug treatments capable of affecting gingival health, or had a history of bisphosphonate use during control visits, as well as pregnant or nursing women and patients with missing information, were excluded. Patients were classified into 2 cohorts according to the implant design:

- group A (TSA): patients treated with implants presenting a neck design without microthreads, with a 1.5 mm machined surface and an internal connection and without platform switching (**Fig. 1a**); and
- group B (TSA Advance): patients treated with implants presenting a neck design with a 0.7 mm machined surface and microthreads with a rough surface and an internal connection and without platform switching (**Fig. 1b**).



Figs. 1a & b

Figs. 1a & b

Macrodesign of (a) TSA and (b) TSA Advance implants.

Surgical procedure

The surgery was performed under local anesthesia with 4% articaine with 1:100,000 epinephrine (Inibsa, Lliçà de Vall, Spain). A crestal incision was made, and a full-thickness mucoperiosteal flap was raised. The drilling sequence recommended by the manufacturer was followed. Implants were placed at a torque of 35 N and positioned with the limit between rough and polished surfaces at crestal level. Suturing was carried out with 4-0 sutures (Supramid, B. Braun, Barcelona, Spain).

All of the patients received postoperative treatment: 500 mg of amoxicillin (Clamoxyl, GlaxoSmithKline, Madrid, Spain) 3 times daily for 7 days, 600 mg of ibuprofen (Bexistar, Bacino, Barcelona, Spain) to be taken as needed, a 0.12% chlorhexidine mouthwash (GUM, Sunstar, Chicago, Ill., U.S.) twice daily for 2 weeks and brushing with a chlorhexidine toothpaste. The sutures were removed 8–10 days after surgery.

Data collection and follow-up

All of the surgeries were carried out by 1 experienced surgeon (MPD) and control visits were performed by 2 trained and calibrated clinicians at prosthesis placement (T^0) and at 6 and 12 months and 3 years after prosthesis placement (T^1).

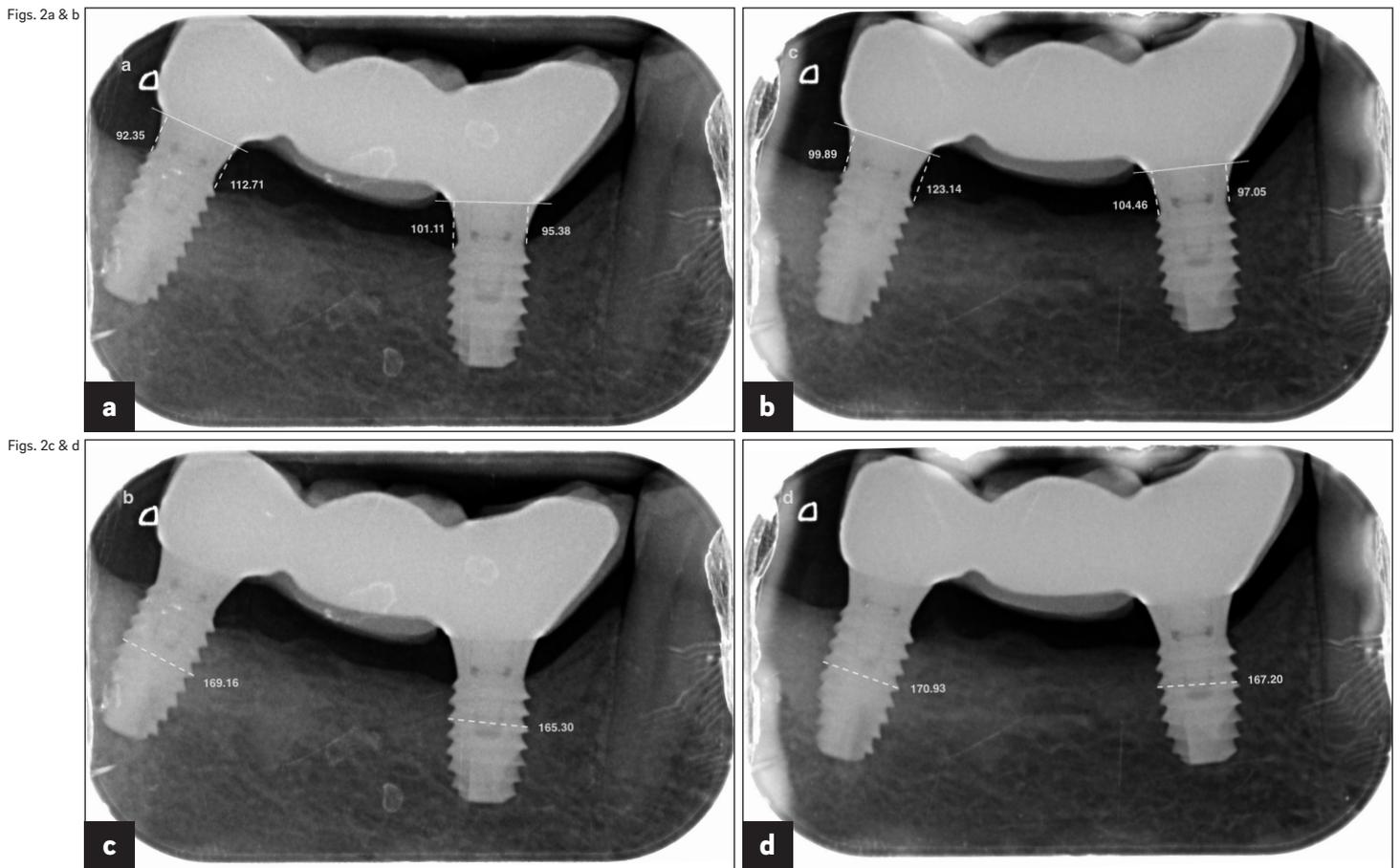
The following variables were collected retrospectively: sex, age, smoking habit (<10 cigarettes/day, 10–20 cigarettes/day, >20 cigarettes/day), implant diameter and length, implant position (anterior, premolar or molar), arch (maxilla or mandible) and antagonist teeth (natural, implant,

absent). A millimetric calibrated periodontal probe (Hawe Neos Probe 1395, Hawe, U.K.) was used to assess the following clinical variables:

- probing pocket depth (PPD), measured from the gingival margin to the deepest part of the periimplant pocket, at 6 locations per implant (mesiobuccal, buccal, distobuccal, mesiolingual/-palatal, lingual/palatal and distolingual/-palatal) choosing the largest value;
- bleeding on probing (BoP);
- presence of mucositis, understood as inflammation of the periimplant mucosa without progressing to crestal bone loss;²² and
- width of keratinized mucosa in the buccal and lingual region.

Intraoral radiographs were used to measure marginal bone loss. Radiographic exploration was carried out using the intraoral XMind system (Groupe Satelec-Pierre Rolland, Bordeaux, France) and the RVG intraoral digital sensor (Kodak Dental System, Atlanta, Ga., U.S.). In order to reproduce the X-ray angles in posterior reviews, XCP positioners were used (DENTSPLY, Des Plaines, Ill., U.S.), placing the guide bar parallel to the direction of the X-ray beam and perpendicular to the digital sensor.

All of the measurements were carried out by 2 examiners (different from the surgeon), who were initially calibrated to evaluate the interexaminer error using the Dahlberg formula and coefficient of variation. Each examiner measured 30 radiographs to evaluate the interexaminer error. The error according to Dahlberg's test ranged between 0.63 and 0.93 mm for the various parameters and the coefficient of variation between 5.2% and 6.4%.



Figs. 2a–d Adimensional measurements of marginal bone loss (a) at prosthesis placement and (b) after 3 years of follow-up. Adimensional measurements across the implant diameter with the objective of calibrating the bone level measurements, knowing the true width of the implant: calibration of (c) the prosthesis placement and (d) the 3-year follow-up radiographs.

Marginal bone loss was measured with the software ImageJ (National Institute of Health, Md., U.S.) to process JPG files as obtained from intra-oral radiographs. Two reference points were marked on each implant at the implant–prosthesis interface and joined with a line representing height 0. Two vertical lines were traced perpendicular to the 0 line up to the first mesial and distal bone–implant contacts (**Figs. 2a & b**). Differences between these perpendicular lines in radiographs taken at the different time points (T^0 and T^1) were used to calculate bone loss. The highest difference value was chosen between the mesial and the distal values. A line was traced across the implant diameter (**Figs. 2c & d**) with the objective of calibrating the periapical radiograph measurements, knowing the true width of the implant.

Statistical analysis

The principal predictor variable was the implant neck designs and neck surface treatments (group A and group B). The outcome variables

of interest were periimplant tissue health and radiographic bone loss after 3 years of functional loading.

A descriptive analysis of the parameters was performed. Sample distribution of bone loss was assessed, and due to lack of adjustment to normal distribution and dependence of observations, the corresponding nonparametric tests were applied: method for longitudinal data of Brunner and Langer, providing an analysis of variance statistic. Generalized estimating equations models were estimated to analyze the probability of the neck design affecting the various clinical variables through the Wald chi-squared statistic. For the variables BoP and presence of mucositis, a binary logistic regression model was estimated. For PPD and width of keratinized mucosa, an ordinal logistic regression model was estimated. The statistical analysis was performed using SPSS (statistical package for Microsoft Windows, Version 15.0, SPSS, Chicago, Ill., U.S.) and R software (Version 2.15.0, R Foundation for Statistical Computing, Vienna, Austria). The

significance level was set at $P < 0.05$. The statistical methodology, with a confidence level of 95% and the median effect size to detect $f = 0.25$, reached a power of 0.81 for the contrast of the interaction effect (homogeneity of bone loss in the groups).

Results

Fifty-five patients fulfilled the inclusion criteria. Patients who had undergone guided bone regeneration ($n = 9$), had immediate implants ($n = 3$), had missing information ($n = 8$) or failed to attend control visits ($n = 6$) were excluded. The final sample consisted of 27 partially edentulous patients, 12 women and 15 men (mean age: 63.5 ± 11.6), with a total of 51 dental implants: 13 patients with 28 implants (group A) and 14 patients with 23 implants (group B). In group A, 22% were smokers, and in group B, 44%. The implant sample was homogeneous regarding the implant diameter, length and position, arch and antagonist dentition (**Table 1**).

No significant differences were observed on evaluating clinical variables (**Table 2**). Higher PPD was measured in group B (5.3 ± 0.9 mm) compared with group A (4.8 ± 1.4 mm), with no statistically significant differences ($P = 0.195$). Group A showed lower BoP (47.1%) compared with group B (60%), although the odds ratio suggested an increased BoP risk with a TSA Advance implant (+27%), but there was insufficient statistical evidence to conclude a true effect ($P = 0.524$). Mucositis was present in 14.3% in group B and 12.5% in group A, and the odds ratio suggested a higher risk of mucositis with a TSA Advance implant (14%), with no statistically significant differences between the groups ($P = 0.916$). The higher score on width of keratinized mucosa was found in group A (3.50 ± 2.44 mm) in comparison with group B (2.7 ± 2.4 mm); however, no statistically significant difference was found ($P = 0.435$). The mean radiographic marginal bone loss with the TSA implants was 0.57 ± 0.55 mm (range: 0.00–2.10 mm) and with the TSA Advance implants was 0.46 ± 0.49 mm (range: 0.00–1.61 mm), and the median was 0.47 mm for the TSA implants and 0.25 mm for the TSA Advance implants (**Table 3**). Despite the greater marginal bone loss around TSA implants, no statistically significant differences were observed ($P = 0.217$).

Discussion

This study evaluated and compared 2 implants with the same body and prosthetic connection, but with different neck designs after 3 years of follow-up to assess the influence of these variables on periimplant tissue health and radiographic bone loss. The present study did not find statistical differences between the 2 implants on evaluating PPD, BoP, presence of mucositis, width of keratinized mucosa and marginal bone loss.

It has been suggested that the initial marginal bone level change occurs as an adaptation of the periimplant bone to the occlusal load.^{23–26} In studies involving a follow-up of over year,^{1,23–26} the greatest bone loss was observed during the first year and then bone loss gradually decreased. The addition of threads or microthreads up to the crestal module of an implant might provide a potentially positive contribution to bone–implant contact, as well as improve preservation of marginal bone.^{4, 20, 23, 27} Shin et al. observed that the most effective design for minimizing marginal bone loss during functional loading was a rough surface with microthreads at the implant neck.¹² Abrahamsson and Berglundh drew a similar conclusion in an experimental study in dogs.²⁸ They found that the degree of bone–implant contact within the marginal portion of the implants was significantly higher for the microthreaded implants compared with the implants with polished necks. Lee et al., in a well-controlled split-mouth study, also found that implants with microthreads showed significantly less bone loss compared with implants without them.² However, although the studied implants were of the same brand and surface characteristics, they differed in their macrodesign: one had a tapered neck and the other had a cylindrical design. In the present study, both implant models, although distinct in thread configuration, had a tapered design. Bratu et al. compared implants of the same brand and with the same dimensions, taper, titanium alloy and surface characteristics but different neck designs: one model with a polished neck and the other with a rough surface and microthreads up to its prosthetic platform.⁵ Unlike the present study, the implants with a rough surface and microthreads displayed statistically significantly less early marginal bone loss and greater bone level stability compared with the polished-neck implants. The results of Piao et al. demonstrated that the amount of marginal bone loss at 12 months of functional loading was significantly

Table 1

		TSA	TSA Advance	P value (chi ²)
Implant diameter (mm)	3.6	2	1	0.547
	4.2	14	15	
	5.5	12	7	
Implant position	Incisor	0	1	0.519
	Canine	1	0	
	Premolar	11	7	
	Molar	16	15	
Arch	Maxilla	0	9	0.802
	Mandible	8	14	
Antagonist	Natural tooth	8	18	0.276
	Implant	10	5	

Table 1

Descriptive statistics of the implant sample.

Table 2

Statistical results regarding periimplant clinical variables.

Table 3

Radiographic marginal bone loss.

Table 2

	TSA	TSA Advance	Odds ratio	P value
Probing pocket depth	4.8 ± 1.4 mm	5.3 ± 0.9 mm		0.195
Bleeding on probing	47.1%	60%	1.27	0.524
Presence of mucositis	12.5%	14.3%	1.14	0.916
Width of keratinized mucosa	3.50 ± 2.44 mm	2.70 ± 2.40 mm		0.435

Table 3

	Total	TSA	TSA Advance
n	51	28	23
Mean	0.52	0.57	0.46
Standard deviation	0.52	0.55	0.49
Minimum	-0.22	0.00	-0.22
Maximum	2.10	2.10	1.61
Median	0.39	0.47	0.25

different among the 3 groups they analyzed: The rough-surfaced microthread implant group showed less bone loss than the rough-surfaced implant group and the machined hybrid design implant group, but these implants had some differences other than the configuration of the coronal part, so these might have impacted on the results.²⁰

Some studies have compared polished-neck implants to rough-neck implants and found significantly greater bone loss with the polished-neck implants.^{4, 12, 13, 25, 29–32} In contrast, others have found no statistically significant differences in bone loss.^{20, 24, 25, 33, 34} Some studies have evaluated the presence of microthreads at the coronal portion using radiographic evaluation of the marginal bone level and found a positive effect in maintaining the marginal bone level for rough-surfaced implants with

microthreads at the coronal portion after functional loading.^{1, 13, 20, 35–36} However, Van de Velde et al. observed that, after 1 year of loading, a microthread design of the implant collar did not seem to improve bone preservation in the mandible.³⁸ Aloy-Prósper et al. in their literature review found that marginal bone loss with polished-neck implants was greater 3 months after implant placement, while bone loss with rough-neck implants with and without microthreads was greater 6 months after insertion of the implants.³⁹ Lang et al. in a consensus report concluded that prospective controlled studies on the effects of different implant designs and surfaces demonstrated that marginal bone levels were generally well preserved after installation of the dental prosthesis (at least for fixed restorations) on a variety of implant types (cumulative bone loss: < 0.5 mm after 3 years).¹¹

Most of the studies measured bone loss from the start of prosthetic loading to the end of follow-up, except Nickenig et al., who measured loss from the time of placement of the implants.¹⁴ They compared smooth and rough implants for restoring missing mandibular molars. In their study, for smooth implants, bone loss progressed from 0.5 mm in the healing period to 1.1, 1.3 and 1.4 mm in the second, third and fifth year of follow-up, respectively. In contrast, for the rough-surfaced, microthreaded implants, bone loss progressed from 0.1 mm in the healing period to 0.5, 0.6 and 0.7 mm in the second, third and fifth year of follow-up, respectively. They found a significant difference in bone level changes, suggesting that rough-surfaced, microthreaded implants more effectively minimized overall marginal bone loss than machined-neck implants did, particularly during the healing period.

Even if some studies have shown less marginal bone loss around implants with a rough neck, these implants favor bacterial plaque retention when exposed to the oral environment, and this in turn would imply an increased risk of periimplant disease such as mucositis or periimplantitis.^{40,41} The relatively smooth implant neck allows the least accumulation of plaque^{18,19} and

is designed as a transmucosal component, thus making the microgap or interface between implant and restoration easily accessible for oral hygiene.²¹

Taking into account the results, it is necessary to highlight the limitations of the present study. Sample size and the lack of randomization could limit generalization of the results. Further studies with a larger sample are needed to clarify the influence of implant neck design on periimplant tissue health and periimplant bone remodeling after medium- to long-term functional loading.

Conclusion

According to the results of the present study, the implant neck designs and neck surface treatments did not significantly influence periimplant tissue health and radiographic bone loss after 3 years of follow-up.

Competing interests

The authors declare that they have no competing interests.

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