Residual Debris Within Internal Features of As-Received New Dental Implants

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Purpose: To investigate residual debris within internal features of new "as received" dental implants. ***Materials and Methods:*** A total of 15 new dental implants representing various dental implant brands were obtained in sealed containers from the manufacturers. Batch numbers and implant types were documented. In a controlled setting, implants were carefully unpacked, and their internal aspects were visually examined. Further analysis involved light microscopy imaging to document and photograph any foreign material. The internal aspect of the implants were sampled with both an endodontic paper cone and a fine bristle brush swab. These were inserted into the implant, rotated three times, then removed and examined under a microscope at 30× magnification. After sampling, some of the brushes and swabs were washed with alcohol to remove debris that could be further examined under magnification. ***Results:*** Inspection of the implants without magnification revealed no visible foreign materials. However, under light microscopy (10× and 30×), all 15 implants exhibited small black particles at various internal sites, including connections, threads, and deep within screw channels. Swabs evaluated at magnification detected what appeared to be metal particles in all 15 implants, ranging from distinct metal shards to smaller particles. ***Conclusions:*** This study suggests that implant manufacturers have not effectively removed all machining debris from within implant bodies, potentially producing prosthetic and clinical complications. *Int J Oral Maxillofac Implants 2025;40:257–261. doi: 10.11607/jomi.11002*

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Ensuring the effectiveness and safety of medical devices, including dental implants, is crucial to their success and requires strict adherence to regulatory standards.[1–4] Manufacturers frequently prioritize meticulous processes to optimize surface properties for osseointegration, underscoring the precision of their manufacturing, cleaning, and sterilization procedures.[5–7] Despite the growing attention to external contamination levels,[8–13] research examining the cleanliness of internal features—notably implant screw threads—is still sparse.

Titanium (Ti) and Ti alloys are widely recognized for their susceptibility to *galling*, which is a phenomenon defined by the American Society for Testing and Materials as "surface damage occurring between sliding solids, characterized by visible roughening and protrusions above the original surface, often involving plastic flow or material transfer."[14] This characteristic renders Ti challenging to machine and unsuitable for many tribologic applications such as screw threads.[15] Chip formation during Ti machining is well documented, with resultant chips often remaining in the cutting area unless adequately cleared.[16] Another significant challenge lies in removing machining debris, particularly in blind-ended compartments and intricate screw threads. The presence of contamination and debris in these areas can result in both mechanical and biologic consequences. The mechanical issues include increased screw thread friction, which jeopardizes connecting surfaces and increases the risk of screw loosening (a prevalent complication).[17–19]

Biologic success may also be dependent upon adequate removal of all Ti particles from within the implant. Ti debris may be inadvertently released within the implant surgical site or thereafter from tribocorrosion effects as a result of movement between the abutment and the implant.[20] *Metallosis* is an inflammatory condition caused by the release of metallic particles and ions into the surrounding tissue.[21] Initially discovered around metal on metal hips, this immune response has also been considered to be instrumental in causing peri-implantitis.[22–26]

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Table 1 The Manufacturer, Implant Type, Lot Numbers, and Debris (Yes/No) Recorded from the Implants Used

				Debris observed	
Manufacturer	Implant brand	Type	Lot no.	Mag. ×30	Brush
Biomet3i	Osseotite	Certain	2.02E+09	Yes	Yes
Dentsply	MIS Seven	Internal Hex	W17005875	Yes	Yes
Dentsply	Astra	Osseospeed	469600	Yes	Yes
Dentinium	Dentinium	Superline II	H27NB6895	Yes	Yes
Dess	Dess	Active Hex	24739	Yes	Yes
Envista	NobelBiocare	N1	12177508	Yes	Yes
Envista	NobelBiocare	Active	761039	Yes	Yes
Glidewell	Glidewell	HT	6216293	Yes	Yes
Henry Schein	BioHorizons	TLXP	1901471	Yes	Yes
Osstem	Hiossen	ETIII	H1E20J021	Yes	Yes
Keystone	Paltop	Dynamic	WO-012259	Yes	Yes
Southern	Southern	Promax	102P01	Yes	Yes
Straumann	Neodent	Titamax GM	EPXH3	Yes	Yes
Straumann	Straumann	BL	GPP21	Yes	Yes
Straumann	Straumann	BLX	ZH110	Yes	Yes

*All implants had some form of debris visible under magnification that could be removed with the fine brush.

The aim of the current investigation was to evaluate the internal aspects of new as-received dental implants for residual Ti remnants.

MATERIALS AND METHODS

Fifteen brand-new, sealed dental implants sourced from various manufacturers were used in this study, and detailed information is provided in Table 1. Two examiners (C.W. and K.H.C.) together evaluated the materials. Upon removal of the external packaging, the implants were maintained in their carriers to minimize handling. Initially, visualization without the use of magnification was employed. Subsequently, a 30× microscope (Model SM, AmScope) equipped with photographic capabilities was used to inspect the connection site and delve deeper into the screw channel shaft down to its base. Any presence of foreign matter was documented, and corresponding photographs were taken.

To further assess the internal screw threads of the implants, debris deposits were collected using fine nylon bristle brushes (Implantbrush, ImplantWise) soaked in isopropanol alcohol. All brushes were inspected under magnification to confirm they were not contaminated and clean prior to being used. The brushes were inserted into the implants and rotated three times clockwise and then counterclockwise. The implants were also sampled using absorbent paper points (Piuma, VastMed) for material around the abutment connection site. Subsequently, the paper points and brushes were examined under 10× and 30× magnification, and observations were recorded. Selective brushes had debris deposits washed off and were further scrutinized under magnification. Larger particles were lightly spray washed with 70% ethanol directly onto glass microscope slides. Smaller particles were collected by washing the brushes onto 4-µm filter paper (Ahlstrom).

RESULTS

No material could be visually seen within the implant internal connection on any of the implants evaluated. However, under magnification, all 15 implants inspected contained material (primarily black spots) located within the base of the connection channel, at the top of the screw threads, and at the base of the screw shaft (Fig 1). Four implants had shards that were believed to be metal machining swarf on the connection surface (Fig 2a), and eight had material visible in the screw thread of the implant (Fig 2b).

Figure 3a shows an example of the brush after insertion into the implant screw channel with metal shards clearly visible, and Figs 3b to 3d show more examples of metal particles trapped in the bristles and on the brush

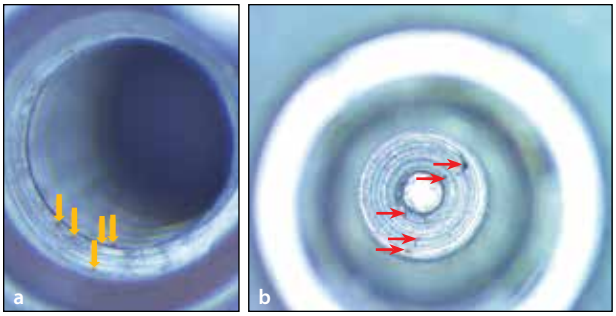

Fig 1 Photographs inside two different implants under magnification. Black spots are highlighted with *arrows*. *(a)* Abutment connection site. *(b)* Base of the screw channel.

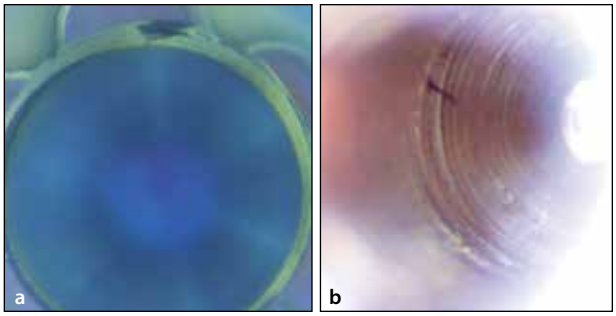

Fig 2 *(a)* Larger machining shard inside connection site. *(b)* Representative sample of debris within implant screw thread.

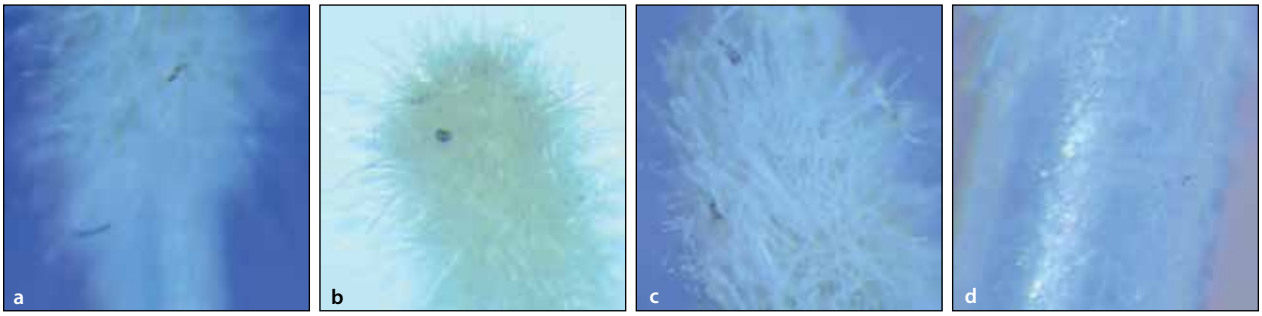

Fig 3 The representative samples show *(a)* multiple shards of Ti in the brush, *(b and c)* particles in the brush, and *(d)* particles on the shank of the brush.

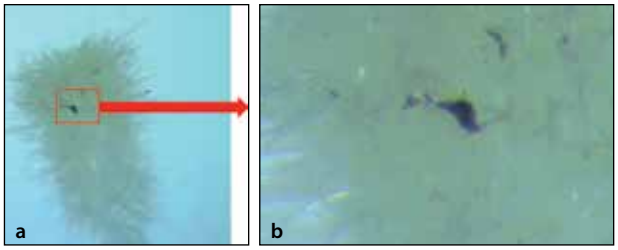

Fig 4 *(a)* Brush image and *(b)* magnified image of *red highlighted area* showing Ti fragments.

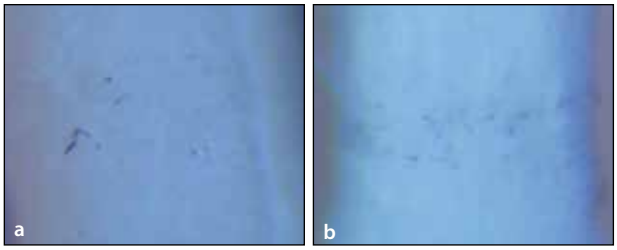

Fig 5 *(a and b)* Fine metal particles picked up on paper points in the connection site of a new implant.

shank. Figure 4 shows a higher-magnification view of one of these Ti particles picked up from the inside of an implant. Finer particles were also noted at the abutment connection sites coronal to the screw thread, which were readily picked up on the paper points (Fig 5). All 15 samples yielded foreign material when swabbed, which was assumed to be Ti particles and machine shavings. The particle size was estimated to be approximately 2 mm for larger shards (Figs 6 and 7a) and around 20 to 30 µm for smaller particles that could be detected (Figs 7b and 7c). One of the implants was subject to scanning electron microscopy (SEM) evaluation (Fig 8), which clearly showed material in the screw threads. Elemental diffraction spectroscopy was used to identify the particles involved, which were determined to be Ti galling particles (see Fig 8).

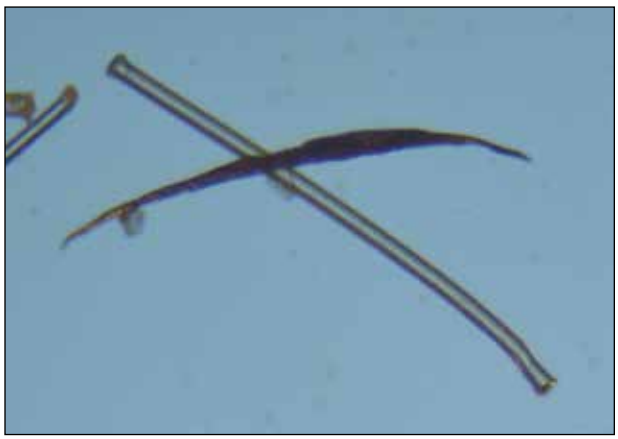

Fig 6 Ti shard washed from a brush onto a microscope glass slide showing a size comparison to the 2-mm-long brush bristles *(clear rod)*.

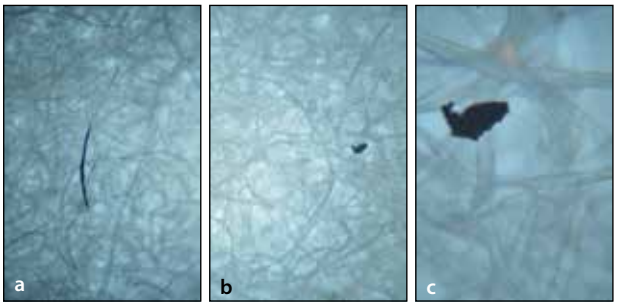

Fig 7 Ti remnants washed onto 5-µm filter paper at *(a and b)* 10× magnification and *(c)* 30× magnification.

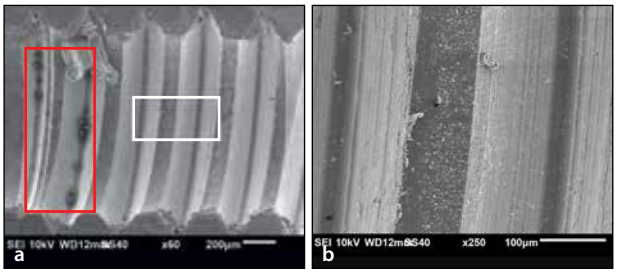

Fig 8 *(a)* SEM of a new sectioned implant with larger particles clearly present in threads *(highlighted red)*. *(b)* Inset of *white box* in part *a* at 250× magnification.

DISCUSSION

The internal aspect of dental implants is often overlooked despite its importance in maintaining screw threads and abutment connections that are free of debris. This can be crucial for preventing mechanical failures such as abutment screw loosening, which is a common complication for single-implant crowns.[17–19] Inadequate removal of post-thread machining—partly due to restricted access within the implant—can lead to debris accumulation, which increases friction and jeopardizes preload (potentially resulting in complications). Screw loosening is cited as the most frequent restorative complication, particularly in single-unit restorations, with literature reporting rates up to 12%.[18] Various factors contribute to this issue, including friction within different sites of the implant-abutment connection.[19] In addition, debris within screw threads can alter friction during screw torque, dissipating energy that would otherwise contribute to preload, and may hinder complete abutment seating.

Interestingly, some implant companies advocate for the use of laboratory screws during restoration fabrication to minimize contamination on the definitive screw. However, if debris is already present within the implant, this approach may not be entirely effective.

The present study revealed the presence of metal machining debris in multiple sites within the implants. It was challenging to quantify the extent of debris accumulation in critical areas, such as within the threads versus the base of the screw channel, where mechanical effects may be less significant. Further investigations are warranted. However, Ti particles not only pose mechanical risks but also have potential biologic concerns.[20–25] Ti particles in the size range between 20 and 30 µm have been associated with negative effects on fibroblasts[28] and osteoblasts.[29]

Recent articles have elucidated the association of Ti particles with inflammatory reactions that have been shown to lead to bone resorption and implant failure. These foreign body reactions are a contributing factor to peri-implant disease, with both ceramic and Ti-based implants known to release particles into surrounding tissue. Ti particles derived from corrosion and tribocorrosion have been shown to activate macrophages that secrete cytokines and stimulate osteoclastic bone resorption, leading to osteolysis.

Although various mechanisms have been proposed to cause Ti release, internal machining debris has not been considered. Recommended methods for debris removal include the use of paper points and directed suction into the implant interior, with novel cleaning devices under development for trapping and removing metal particles.[29]

Limitations of the present study include the small sample size and the fact that only one of each implant type was sampled. There is also a need for further investigation into the nature of the debris encountered to confirm in all cases that it was parent metal derived from the implant. It seems rational that industry and clinical methods should be developed to ensure comprehensive removal of all debris from the internal aspect of implants. If industrial methods do not change and removal of such particles is undertaken clinically, it must be done with care so as not to affect the biocompatibility of the implant or host that may occur by spreading metal particles into a surgical site.

In the words of author Tomas Albrektsson, "The weak point is, of course, that it is difficult to state whether a certain ionic or other remnant on implant surfaces really is dangerous or not, at the same time as I assume we all would prefer 'clean' implants."

CONCLUSIONS

All implants evaluated in the present study contained debris within the internal aspects, indicating inadequate attention to cleanliness by manufacturers. This underscores the need for improved cleaning methods and stricter quality-control measures in dental implant production.

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The authors report no conflicts of interest.

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