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Morphologic Analysis of Metal Particle Release Following TAD Insertion

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Objectives

During orthodontic treatment, TADs can be used to provide skeletal anchorage. They are made of biocompatible, corrosion-resistant alloys. Due to friction and stress, metal particles may be released during insertion. This study sought to quantify and characterize metal particle release during TAD insertion to better understand potential biological and allergic implications associated with metal exposure.

Materials and Methods

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- Metal particle release was assessed in vitro using Dentaurum® TADs (n=20; 10 mm length/1.6 mm diameter) and artificial bone blocks (Sawbones) mimicking cancellous bone (3 mm thickness, 30 lbs/ft³ density).
- Bone block surfaces were examined before and after hand-torquing the TADs into a vice.
- Stability was confirmed and synchrotron radiation X-ray fluorescence spectroscopy analyzed metal composition at coronal, middle, and apical osteotomy segments (n=120).
- Statistical analysis was conducted using comparative analyses via an ANOVA with a 0.05 p-value.
- TADs from Dentaurum Inc. (n=2) and American Orthodontics Inc. (n=2) were hand-torqued into new artificial bone blocks of the same thickness and density were used to further assess metal particle release.
- Scanning electron microscopy (SEM) was used to visualize surface morphology and identify particle morphology at the bone-block interfaces.
- Energy-dispersive X-ray spectroscopy (EDS) was also conducted to provide complementary elemental analysis to corroborate the XRF findings.

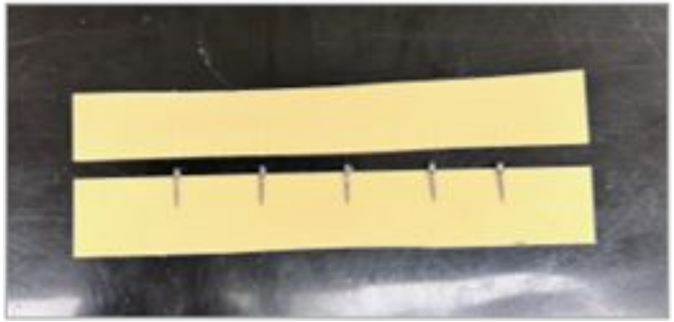

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Table 1. Descriptive statistics summarizing the presence of metal nanoparticle at the coronal, middle. and apical osteotomy interface sites (n=120).

location		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
coronal	titanium	40	6832.3	4160.1	657.8	5501.8	8162.7	1920.0	20000.0
	Aluminum	40	14255.0	11818.4	1868.7	10475.3	18034.7	.0	26000.0
	Nickel	40	28522.5	1942.0	307.1	27901.4	29143.6	24600.0	33600.0
	Total	120	16536.6	11592.2	1058.2	14441.2	18632.0	.0	33600.0
middle	titanium	40	3198.5	3049.3	482.1	2223.3	4173.7	.0	11400.0
	Aluminum	40	14985.0	6407.3	1013.1	12935.8	17034.2	.0	19000.0
	Nickel	40	13807.5	1489.9	235.6	13331.0	14284.0	11600.0	18100.0
	Total	120	10663.7	6749.9	616.2	9443.6	11883.8	.0	19000.0
apical	titanium	40	914.5	2619.5	414.2	76.7	1752.3	.0	12400.0
	Aluminum	40	13740.0	6424.1	1015.7	11685.5	15794.5	.0	17500.0
	Nickel	40	9047.8	2366.8	374.2	8290.8	9804.7	2980.0	13600.0
	Total	120	7900.8	6776.4	618.6	6675.9	9125.6	.0	17500.0

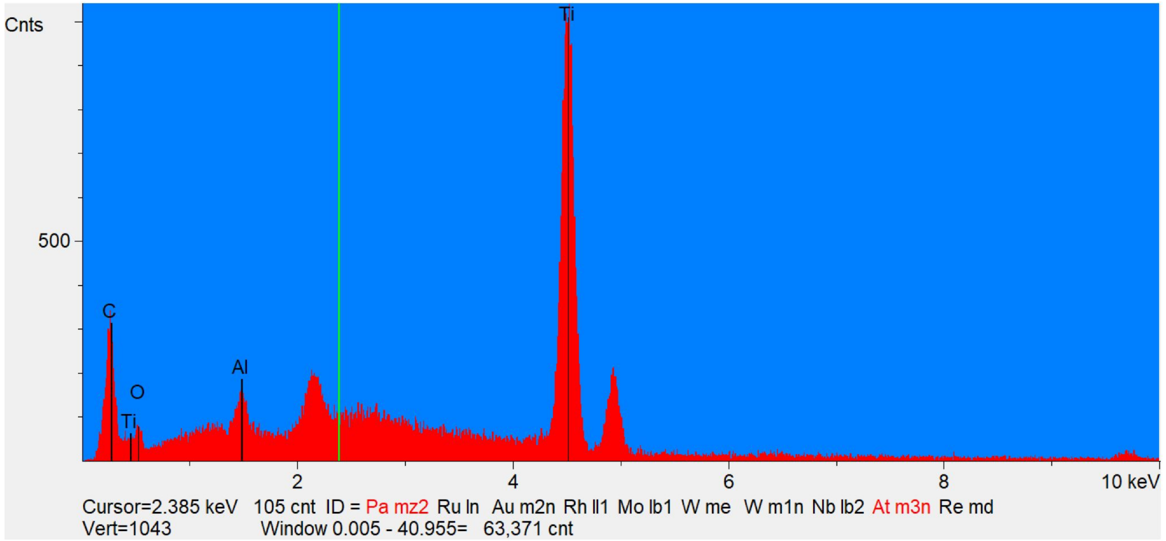

Figure 3. Sample of an Energy Dispersive X-ray Spectrometry (EDX) to show the metal elements found on the osteotomy

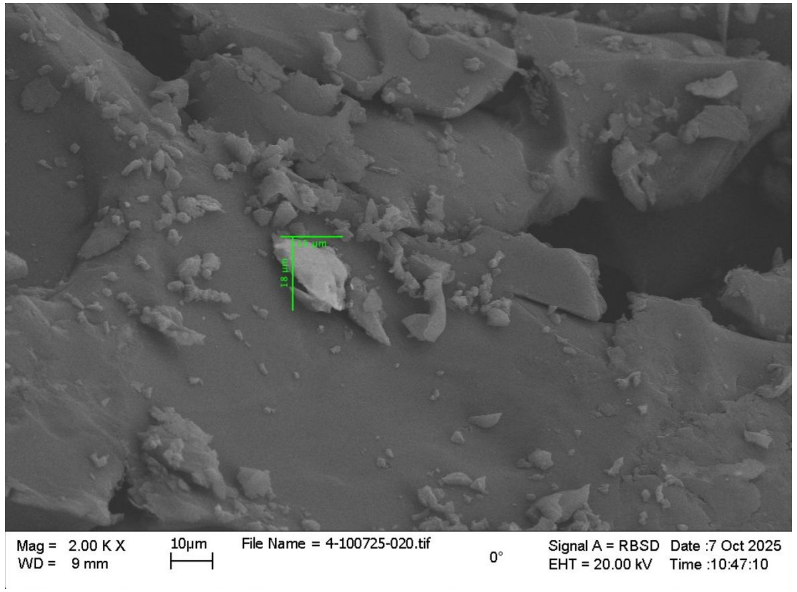

Figure 4. Sample of Scanning Electron Microscopy highlighting a metal particle that was released upon insertion of TAD

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Conclusion:

These findings suggest that mechanical insertion of TADs in vitro can induce metal release with possible implications for local tissue response and hypersensitivity risk. Given the potential for biological reactivity, further in vivo studies are warranted to assess the clinical relevance of metal particle release.