Retrieval Analysis of Tibial Insert in Knee Prostheses: Influence of Manufacturing and Material on Post Damage

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INTRODUCTION: The design, material, and manufacturing method are parameters that can influence the durability of TKA tibial inserts. Posteriorly stabilized inserts (PS) can exhibit severe wear on the post surface, especially on the posterior face, due to the post-cam mechanism. The objective of this study is to assess the mechanical wear and oxidation index of tibial insert post surfaces with different designs, grouped by service time.

METHODS: Four primary PS TKA implants with a service time of 5 years or less were randomly selected (Group A: A1, A2, A3, and A4), along with four implants with a service time exceeding 5 years (Group B: B1, B2, B3, and B4). Project data and clinical information related to the inserts can be observed in Table of Figure 1. The medial, anterior, lateral, and posterior faces of the posts on each insert were evaluated, following Hood's damage modes and severity criteria, with a 10x magnification. Additionally, Fourier Transform Infrared spectroscopy (FTIR) was employed to calculate the Oxidation Index (OI) for the anterior and posterior faces, in accordance with ASTM F2102-17.

RESULTS SECTION: The severity results of the post modes per tibial insert can be observed in Figure 2, while the results per post face and design can be seen in Figure 3. The oxidation index results were higher than 1 only for the posterior faces of the posts in inserts A1, B1, and B2. The femoral components were cemented and made of CoCr alloys.

DISCUSSION: As expected, on average, the severity sum values (total) and oxidation index were higher in Group B due to the longer service time. However, some results deviated from the pattern, such as insert A1 due to its high oxidation index and insert 4 due to the elevated total severity. The damage mode with the highest severities was abrasion, followed by delamination and scratching. Typically, abrasion is considered the most severe mode in the literature. Delamination mode might be associated with the total severity of each insert, as it was present only in the four inserts with the highest sums (A1, A4, B1, and B2). This damage mode affects the insert's macroscopic geometry and leads to the release of delaminated parts, usually in the form of layers or leaves. The high sum of severities in inserts A1, B1 and B2 could be attributed to its high oxidation index. When the oxidation index exceeds 1, the polymer's mechanical properties are sufficiently degraded to make the insert more fragile. Regarding insert A4, the oxidation index was low, but the patient had a BMI exceeding 40 and a weight exceeding 100 kg. In both cases, A1 and A4, the revision of TKA was due to aseptic loosening, which might have been caused by particles resulting from higher wear, increasing the occurrence of osteolysis. Regarding the design (Figure 3), the three PEUAPM inserts manufactured by direct molding showed better performance in terms of service time, even in patients with obesity. These three inserts were also the only ones with a maximum flexion design of 125°. Among the XLPE inserts manufactured by machining, only one had a service time exceeding 5 years, insert B3, which was the only mobile-base insert. In other studies, the mobile base might yield better results, but in terms of design, in this study, the maximum flexion angle could be more closely associated with less early failures. Utilizing macroscopic damage assessment and oxidation index to evaluate tibial insert wear can provide insights into the selection of tibial insert designs, even when considering clinical information.

SIGNIFICANCE/CLINICAL RELEVANCE: Utilizing macroscopic damage assessment and oxidation index to evaluate tibial insert wear can provide insights into the selection of tibial insert designs, even when considering clinical information.

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IMAGES AND TABLES:

Figure 1

	GROUP A				GROUP B			
	Insert A1	**Insert A2**	**Insert A3**	**Insert A4**	**Insert B1**	**Insert B2**	**Insert B3**	**Insert B4**
Clinical information								
patient weight	78,0 kg	*	62,8 kg	102,0 kg	100,8 kg	70,0 kg	72,7 kg	80,0 kg
BMI	33,3	*	23,6	40,9	28,2	25,7	31,5	35,6
Reason for TKA revision	Aseptic loosening	Periprosthetic fracture	Stiffness	Aseptic loosening	Infection	Instability	polyethylene wear	Instability
Project parameters								
Manufacturing method	Molded	Machined	Machined	Machined	Molded	Machined	Machined	Molded
Material	UHMWPE	XLPE	XLPE	XLPE	UHMWPE	UHMWPE	XLPE	UHMWPE
Maximum flexion angle	145°	150°	150°	150°	125°	125°	155°	125°
Bearing	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Mobile	Fixed

**: Without data.*

Figure 2

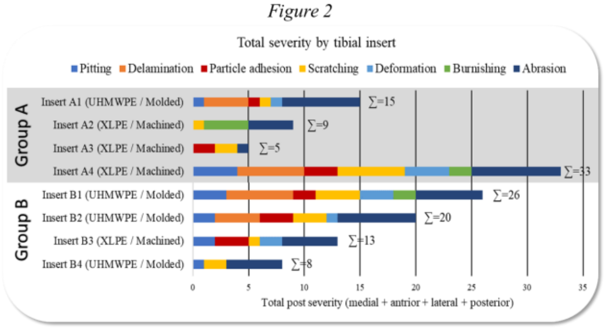

Figure 3