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Research Article

The Retrospective Survey of Corrosion Amount Inside The Tissue of Spinal Surgery Used Titanium Pedicle Screws in Time

Spinal Cerrahide Kullanılan Titanyum Pedikül Vidaların Zamanla Doku İçerisindeki Korozyon Miktarının Retrospektif Olarak Araştırılması

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Abstract: Our study is aiming retrospective survey of the corrosion resistence of above-stated silver and hydroxyapatite covered pedicle screws depending on routinely surgery used Ti and Ti-6Al-4V compounded pedicle screws. 32 pedicle screw coverings in different sizes removed after the revision surgery were separated into three groups (Ti-6Al-4V, Silver Covering and Hydroxyapatite Covering). Screws in every group were measured in order of diameter (mm) and severity (gram). The implanted residence times (day) of pedicle screws in patients were recorded by using patient records. According to the results, we observed that silver and hydroxyapatite covered pedicle screws and time have a correlation relation in a positive way. However, this situation is total opposite for Ti-6Al-4V pedicle screws. Any correlation relation in a positive way between severity difference and time wasn't found in any pedicle screw group. Hydroxyapatite and silver can not be used unattended in the body because of their biomechanic resistance and various toxic features. When they are added on to the Titanium screws with different covering techniques, biocompatible and antibacterial surgical instruments are obtained. Our purpose is improving very image of hydroxyapatite and silver covering materials with succesful results we gained.
Keywords: Spinal Surgery, Pedicle Screw, Hydroxyapatite, Silver, Nanocoating.

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Özet: Çalışmamız, yukarıda belirtilen gümüş ve hidroksiapatit ile kaplanarak üretilen pedikül vidaların cerrahide rutin olarak kullanılan Ti ve Ti-6Al-4V alaşımı pedikül vidalara göre korozyon direncinin retrospektif araştırılmasını amaçlamaktadır. Revizyon cerrahisi sonrasında çıkartılan, farklı boyutlardaki 32 adet pedikül vida kaplama türlerine göre üç gruba (Ti-6Al-4V, Gümüş kaplama ve hidroksiapatit kaplama) ayrılmıştır. Her bir gruptaki vidaların sırasıyla çap (mm) ve ağırlıkları (gram) ölçülmüştür. Hasta kayıtları kullanılarak, pedikül vidaların hastada implante kalma süreleri (gün) kaydedilmiştir. Elde edilen verilerde, gümüş ve hidroksiapatit kaplı pedikül vidaların süre ile pozitif yönde bir korelasyon ilişkisi olduğu gözlenmiştir. Ti-6Al-4V pedikül vidalarda ise bu durum tam tersidir. Elde edilen verilerde, hiç bir pedikül vida grubunda ağırlık farkı ve süre arasında pozitif yönde bir korelasyon ilişkisi gözlenememiştir. Biyomekanik dayanımları ve çeşitli toksik özellikleri nedeniyle vücutta tek başına kullanılamayan hidroksiapatit ve gümüş, farklı kaplama teknikleriyle Titanyum vidaların üzerine entegre edildiğinde biyouyumlu ve antibakteriyel cerrahi enstrümanlar elde edilmektedir. Çalışmamızdan elde ettiğimiz başarılı veriler ile hidroksiapatit ve gümüş benzeri kaplama materyalleri geliştirmeyi hedefliyoruz.
Anahtar Kelimeler: Spinal Cerrahi, Pedikül Vida, Hidroksiapatit, Gümüş, Nanokaplama.

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1. Introduction

316 stainless steel and Co-Cr mixtures, especially used in orthopedic and dental applications among metallic implant materials, contain Ni, Cr and Co ions and release ions which have toxic effect to surrounding tissues by corroding in the body. Besides, elastic modulus values, an important feature for implant success, are high for the bone and this situation causes stress shielding effect and prothesis softening (1).

Titanium (Ti) and Ti compounds are frequently preferred materials in biomedical implementations because of their high strength, low density, high corrossion resistance, full inertness in body tissue and integrable to the bone and other tissues features. Moreover, they have closer modulus values to the bone in comparison with other metallic materials. There are many Ti compounds prepared for biomedical implementations contain elements like aluminium (Al), vanadium (V), molibden (Mo), zirconium (Zr), niobium (Nb), palladium (Pd) and tin (Sn). Especially, commercially pure Ti and Ti-6AI-4V compounds are commonly used in implant applications.

Titanium and Ti compounds are reactive metals. When they are exposed by oxygen, a steady oxide layer with 3-10 mm thickness spontaneously occurs on the surface. A couple of oxide layer that have different stochiometry form on the titanium surface. These are TiO, Ti2O3 and TiO2. The most steady one is TiO2. TiO2 exists in 3 different crystal structures (anatase, rutile and brookite) and an amorph shape (2). TiO2 is one of the strongest metals against corrosion because it's very determined to the chemical effects, fast renewable and hardly sticky to the substrate (3).

Although titanium biomaterials have many powerful characteristics, there are some problems during clinical implementations. The current Ti and Ti compounded implant materials are insufficient for long term clinical implementations. To cope with these problems, various layer executions and modifications are applied to the materials.
The most effective method to resolve implant based problems is totally inhibiting bacteria contamination on the implant surface. Antibacterial surface coverings are developed in order to avoid primary coherency of the bacterias to the implant surface. Coverings are in two groups as active and passive coverings which depend on antibacterial agent release (4). Silver inorganic antimicrobial agent included covering is the most common method.

The main purpose of metallic implant covering is increasing osteointegration by maintaining mechanic features like conveyor feature. Bone attached characteristic bioactive ceramics, apatites, calsium phosphates, bone morphogenetic proteins (BMP) treated osteoconductive and osteoconductive materials are used in implant surface covering and many studies are done (5).

Our study is aiming retrospective survey of the corrosion resistence of above-stated silver and hydroxyapatite covered pedicle screws depending on routinely surgery used Ti and Ti-6Al-4V compounded pedicle screws.

2. Materıal and Method

In our study, we used pedicule screws taken from 24 revision surgery treated adult patients in DPU Kutahya Evliya Celebi Training Research Hospital, Department of Brain and Nerve Surgery between 1st of December 2017 – 30th of December 2018.

Diameter and Severity Measurement of Pedicule Screws

32 pedicle screw coverings in different sizes removed after the revision surgery were separated into three groups (Ti-6Al-4V, Silver Covering and Hydroxyapatite Covering). Screws in every group were measured in order of diameter (mm) and severity (gram). The implanted residence times (day) of pedicle screws in patients were recorded by using patient records.

To diameter measurements of every original size known revision screw, a pre-setting tender length linear measure system which makes inner and outer diameter measures inside workshop was used with 0,7 μm sensitively. 3 different measures were taken from the pitch part of the pedicule screws showed in Shape-1. According to the average value, an analyze was made. Also, a proffessional laboratory bascule that makes measurement with 6 μm sensitively was used for severity measuring.

In consideration of the results, a correlation was founded between corrosion amount and time for three different pedicule screw groups. Moreover, corossion amounts of every pedicule screw group were compared with other one and then their superiorities to each other were examined.

Ki-square test was used for the statistical analyzes of study data. $p<0.05$ value was accepted as statistical meaningful. Numerical variables were explained as average ± SD and categorical variables were explained as number and percentage.

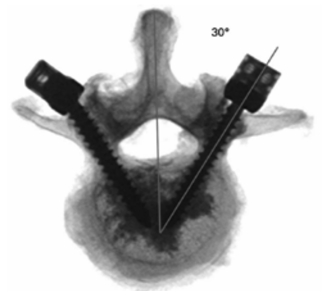

Figure 1. fluoroscopically image of pedicule screw

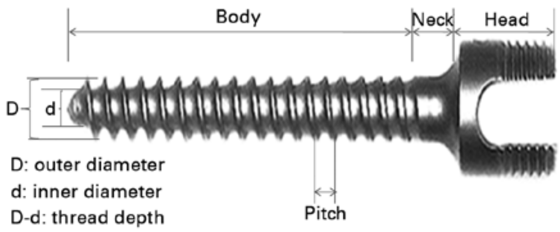

Figure 2. Parts of a pedicule screw

3. Results

The measured diameter and the original diameter of 32 screws in three different screw groups were showed in Table-1. The correlation relation among the difference between the expected and the measured values and implanted time on the patient were analyzed.

According to the results, silver and hydroxyapatite covered pedicule screws have a correlation relation with time in a positive way. It's a totally opposite situation for Ti-6Al-4V pedicule screws.
Silver and hydroxyapatite make chemical bond with the bony tissue around the pedicule screw in time and this occasion leads increasing osteointegration in that area. That shows the obtained correlation ratio is statistically meaningful. Likewise, correlation ratio is statistically meaningful in a negative way because Ti-6Al-4V pedicule screws are long-wearing and bioinert.

When we analyze the silver and hydroxyapatite covered pedicule screws in between each other, we observed that the variance between diameter change of the hydroxyapatite covered screws and time have a higher correlation ratio. This correlation difference increases hydroxyapatite covering osteointegration feature and it's meaningful because silver coverings increase antibacterial feature.

Table 1.
The correlation values related with diameter measurements and time of the three different pedicule screws

	Screw No	Measured Screw Dıameter (mm)	Orıgınal Screw Dıameter (mm)	Dıfference (mm)	Tıme (Day)	Correlatıon Ratıo
	1	7,13	7,20	0,07	1460	
	2	6,14	6,20	0,06	1523	
	3	5,40	5,50	0,10	1632	
	4	6,28	6,50	0,22	1751	
	5	5,00	5,00	0,00	1698	
Ti-6Al-4V	6	7,18	7,20	0,02	1354	-0,0728
	7	5,46	5,50	0,04	1482	
	8	5,62	6,00	0,38	1205	
	9	5,94	6,00	0,06	1673	
	10	6,40	6,50	0,10	1694	
	11	6,46	6,50	0,40	1736	
	1	6,42	6,50	0,08	1713	
	2	5,48	5,50	0,02	1659	
Silver Coating	3	5,46	5,50	0,04	1418	
	4	6,00	6,00	0,00	1792	
	5	6,16	6,20	0,04	1633	0,0665
	6	6,38	6,50	0,12	1765	
	7	5,38	5,50	0,12	1886	
	8	5,40	5,50	0,10	1432	
	9	5,48	5,50	0,02	1562	
	10	6,00	6,00	0,00	1813	
	1	6,00	6,00	0,00	1563	
	2	5,44	5,50	0,06	1735	
	3	5,40	5,50	0,10	1493	
	4	5,48	5,50	0,02	1558	
	5	5,46	5,50	0,04	1795	0,1409
	6	6,48	6,50	0,02	1380	
HA Coating	7	5,40	5,50	0,10	1492	
	8	6,12	6,20	0,08	1811	
	9	5,42	5,50	0,08	1925	
	10	6,48	6,50	0,02	1629	
	11	6,18	6,20	0,02	1782	

Time and diameter variables of every kind of pedicule screw were created in Shape 3-4-5. When we analyze the graphics, any stable formulation wasn't obtained between diameter difference and time for any screw group. Considering a healthier relation between screw diameter and time can be possible by increasing the number of samples.

According to the obtained data, there isn't any correlation relation in a positive way between severity difference and time in all three pedicule screw groups. Negative correlation ratios given in the Table 2 show that there is a reverse relation between time and severity of pedicule screws.

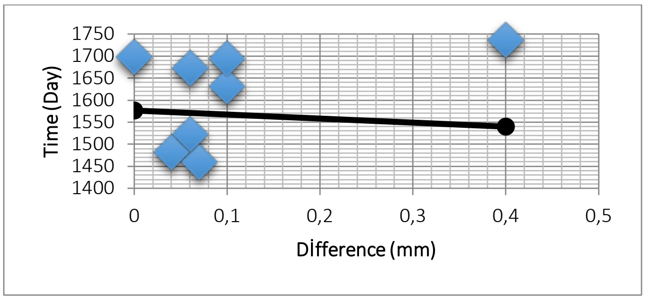

Figure 3. A graph showing diameter and time changings of Ti-6Al-4V screws

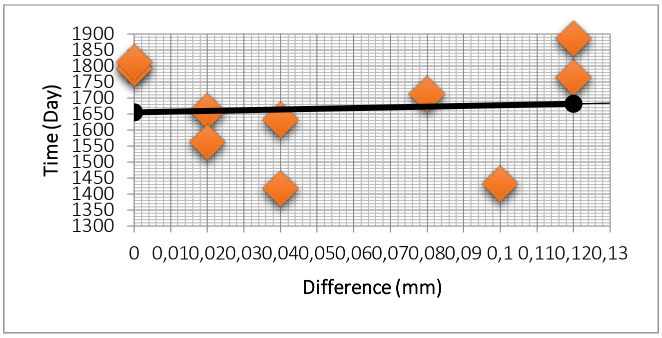

Figure 4. A graph showing diameter and time changings of silver covered screws

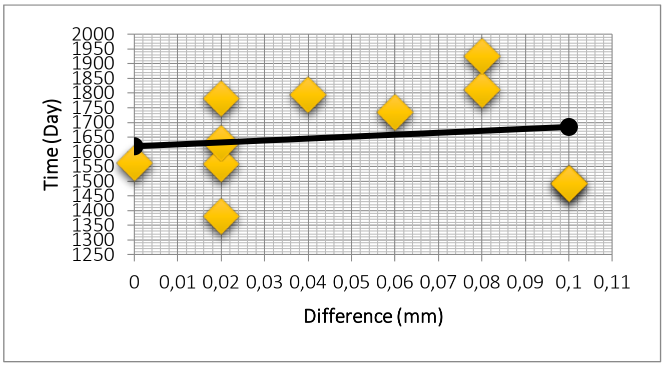

Figure 5. A graph showing diameter and time changings of hydroxyapatite covered screws

Table 2.
The correlation values of three different pedicule screws related with severity measurements and time

	Screw No	Measured Severity (Gram)	Original Severity (Gram)	Difference (Gram)	Time (Day)	Correlation Ratio
Ti-6Al-4V	1	7,0498	7,2000	0,15020	1460	-0,4792
	2	7,1487	7,2000	0,05130	1523	
	3	8,1333	8,2000	0,06670	1632	
	4	8,8455	9,0000	0,15450	1751	
	5	8,6421	9,0000	0,35790	1698	
	6	11,0377	11,5000	0,46230	1354	
	7	6,0399	6,5000	0,46010	1482	
	8	9,2217	9,5000	0,27830	1205	
	9	8,8117	9,0000	0,18830	1673	
	10	6,4437	6,5000	0,05630	1694	
	11	6,4371	6,5000	0,06290	1736	
Silver Coating	1	6,3940	6,5000	0,10600	1713	-0,1865
	2	5,6634	6,0000	0,33660	1659	
	3	5,7401	6,0000	0,25990	1418	
	4	6,8923	7,0000	0,10770	1792	
	5	6,8381	7,0000	0,16190	1633	
	6	6,4598	6,5000	0,04020	1765	
	7	5,9335	6,0000	0,06650	1886	
	8	5,9393	6,0000	0,06070	1432	
	9	7,5902	8,0000	0,40980	1562	
	10	6,6154	7,0000	0,38460	1813	
HA Coating	1	10,2865	10,5000	0,21350	1563	-0,5041
	2	5,4840	5,5000	0,01600	1735	
	3	5,7582	6,0000	0,24180	1493	
	4	4,1775	4,5000	0,32250	1558	
	5	8,8870	9,0000	0,11300	1795	
	6	6,5956	7,0000	0,40440	1380	
	7	7,4167	7,5000	0,08330	1492	
	8	7,0792	7,2000	0,12080	1811	
	9	8,0338	8,2000	0,16620	1925	
	10	9,8435	10,0000	0,15650	1629	
	11	9,2321	9,5000	0,26790	1782	

Time and severity difference variables of every kind of pedicule screw were created in Shape 6-7-8. When we analyze the graphics, any stable formulation wasn't obtained between diameter difference and time for any screw group. Considering a healthier relation between screw diameter and time can be possible by increasing the number of samples.

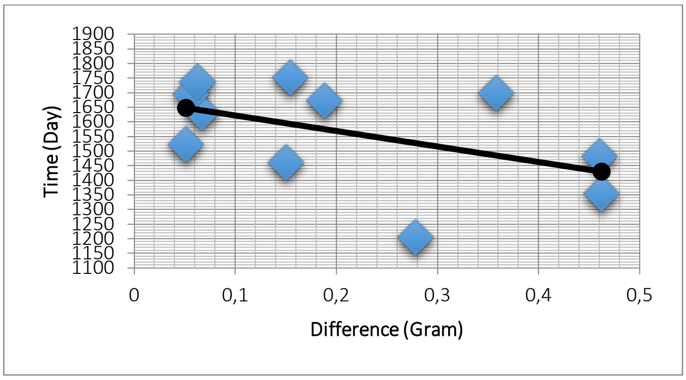

Figure 6. A graph showing severity and time changings of Ti-6Al-4V screws

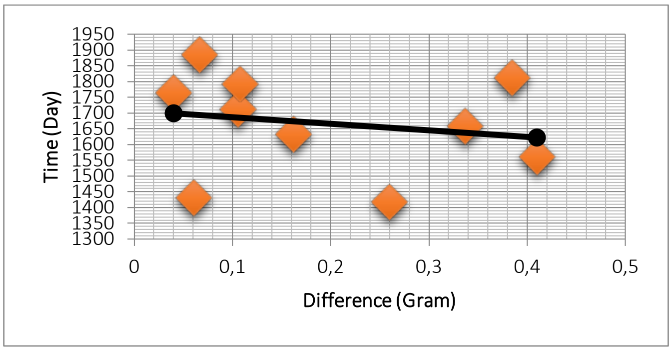

Figure 7. A graph showing severity and time changings of silver covered screws

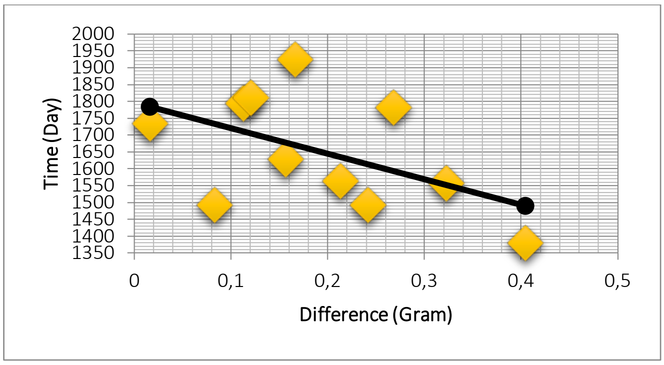

Figure 8. A graph showing severity and time changings of hydroxyapatite covered screws

4. Discussion

Transpedicular screw fixation is the golden standard of reconstruction surgeries which are treated after degenerative conditions of spinal deformity lumbar vertebras, traumatic fractures and spinal tumor resection. However, pedicule screws' deformation in time affects the new bone tissue formation and recovery time. Developing surgical techniques and various material using cause an increasing stability (7). Mechanic stabilization made with rigid fixation generally increases the fusion amount but total conjugation of bone structure can not be provided (8). Therefore, the new covering materials that can adjust high level of biocompatibility along with decreasing postop complications are investigated on these days (9). Hydroxyapatite covering of pedicule screws has an effective role on building bone implant interface. Moreover, there is an observation that the risk of infection is decreased at the rate of 91,6% on silver covered pedicule screws (10).

5. Conclusıon

Our study searched about the changes of spinal surgery used standard pedicule screws and hyroxyapatite or silver covered screws in time. Because of biomechanic resistance and different toxic features, hydroxyapatite and silver can not be used alone in the body. When they are integrated on Titanium screws with different covering techniques, biocompatible and antibacterial surgical instruments are obtained. We aim developing covered materials suchlike hydroxyapatite and silver with successful results we had.

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