Sustainable material for knee replacement using topsis method

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Abstract. Sustainable materials are required for providing good design to products and proper application. It is economical, environmentally friendly and is widely accepted in society. The demand for knee replacement can be fulfilled with fulfilling aesthetic design and bio-compatibility of knee replacement. As the knee is the most important part of the body and the mobility of a person depends on its proper surgery and sustainable knee implants, in this paper an effort is made to design the knee implants using solid work design and the best implant material is selected Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method. The selection criteria of sustainable implant materials are dependent on properties like mechanical property, bio-compatibility ness and cost of the material , which helps in selection of best material, where as solid work helps in designing, optimizing and simulating sustainable knee implant design before manufacturing. For analyzing the material selection process, durability, performance and patients ' requirements are taken care of. Case studies and examples demonstrate the effectiveness of this approach in advancing orthopedic implant design and material selection, ultimately contributing to the improvement of patient care in the field of orthopedic surgery.

Keywords: TOPSIS Method, Entropy method, MCDM method, Knee replacement, Sustainable manufacturing.

1 Introduction

Heavy physical activity can be distinguished as the intense muscular efforts and external resistance, provides an idiosyncratic challenges to the human body. This domain of heavy physical activity encloses with a wide range of different physical activities, starting from high-intensity training to weightlifting. Other than these are physical activity, there are sudden sports such as sprint(running), javelin throw, shot put and different other outdoor sports such as cricket, football, hockey, volleyball, basketball, etc. Comes in the same

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domain. While doing these heavy physical activities, every individual or sport person have to assiduously engage their body muscles, bones and tissues against different external forces.

Bio mechanical analysis can be elucidated as the mechanical study of different aspects related to living organisms in the context of physical activities and movements. In the monarchy of the sports and exercise science, the fundamental aim is to analyze and identify the different movement pattern of different person. By studying and analyzing the biomechanics, a filter technique can be developed by coaches or athletes to optimize the performance of the athletes. With the help of bio mechanical analysis, different risky movement patterns can be pinpointed which may leads to different severe injuries. Addressing these factors provides an unique passage to design a strategies to avoid the risk of hackneyed injuries. Analyzing and studying different movement patterns help individual to adapt an optimal techniques for safety. Bio mechanical analysis under personalized training programs provides an unique biomechanics profile for every individuals. To optimize training outcomes and minimize the risk of injury, a specific movement pattern should be followed during different exercises. To design the customized sport equipment, footwear, and other gear, the bio mechanical analysis plays a viral role. Taking a real life example, an woman ascending a stairs undergoes different challenges such as muscle imbalance, knee alignment, wider hips and age-related challenges.

In this growing era of bio material, knee replacement can be a satisfactory alternative or can also called a solution for those have a difficulty in their knees due to these heavy exercises or due to some heavy work in their day to day life. But in recent times, selecting and developing any material using bio material have become a great challenge. Among all other bones implant, the number of knee replacement is growing day by day.

The success of these procedures critically hinges on the selection of sustainable materials for the knee implant and the material impacts on sustainable manufacturing process as it directly influences the implant's performance, durability, and compatibility within the human body. A set of different bio material can be selected and then they can be prioritized on the basis of their physical, mechanical, chemical, thermal, biological, electrical, etc. Properties.

The main motivation behind writing this paper is to address the crucial challenges material selection of knee replacement . Research in this area may lead to find different properties of bio material along with suitable places to use them. Understanding and analyzing the topsis method can be a novel approach to contribute in the materiel selection of knee replacement. This research aims to contribute in the academic literature and expand knowledge about different properties of bio material along with the topsis method. Research in this area will spread awareness and promote the practice of knee replacement.

Introducing sustainability to knee replacement involves considering the environmental, social, and economic impacts associated with the manufacturing, usage, and disposal of knee replacement implants and associated materials. Sustainable manufacturing processes aim to minimize energy consumption, waste generation, and emissions. Implementing renewable energy sources and efficient production techniques can contribute to sustainability. Designing knee replacement implants for longevity and durability reduces the need for frequent replacements, thus lowering overall resource consumption and waste generation. Additionally, durable implants contribute to better patient outcomes by minimizing the need for revision surgeries. Sustainable knee replacement begins with the choice of materials used in manufacturing. Opting for materials with lower environmental impact, such as recycled metals or biodegradable polymers, can reduce the carbon footprint of the implants.

2 Literature Review

In the year 2019, Peto et al. In their paper said that the knee joint consist of ligament, small bones, tibia, fibula, muscles, cartilages etc. Again in the same year, C.V.R.Meenakshi et al. pointed that while performing different activity in our day to day life these joints move not only in the forward direction but also in the backward direction. Carr et al. (2009) in their paper noted that there are more than 140 types of implant model are available after the advancement in the field of implant technology in the year 1977.
Carr et al.(2009) and Abitha et al.(2020) suggested in their paper that UHMWPE, poly-ether-ether-ketone (PEEK), titanium alloys, ceramics and cobalt, etc. which are bio compatible are currently used for knee implantation. In 2020, Herbster rt al. pointed on their paper that Hyper sensitive metal and polyethylene are toxic for human body. Hence to over come this problem, different manufacturers offer coated implant..Kun et al. In their paper said that during the static as well as the dynamic loading condition , numerous point should be studied.
In the year 2019, Koh et al. In their study found that bio materials are those sustainable material which can replace the elements of human body or have human tissue and body fluid interaction. Kar et al.(2020) suggested that PMMA(polymethyl methacrylate) is non-toxic for human body,and is stiff as well as fatigue resistant.
Hospital et al. found that alloys are less bio compatible due to porosity and corrosion susceptivity. Deenoi et al. pointed that for the knee implantation , titanium alloys for femoral component are used.

Challenges or boundary of knee implantation:

1. Corrosion:
Corrosion is one of the foremost challenge of knee implant, which may lead to several complication such as implant failure and inflammation, etc. To ensure long term success of the implant as well as the safety of the patient, the material we use should be corrosion-resistant or noncorrosive in nature. In demanding to the physiology environment of the human body, material like titanium alloys should be used.
2. Ductility:
To withstand the stress and deformation in the human body, the implant materials should be ductile in nature. Hence, we can say that the ductility is also an important factor in selection of materials for knee implants. Better absorb of energy can be shown in the material having adequate ductility. They can also adapt mechanical forces as well as reduce the risk of fractures or failure.
3. Strength:
The material must bear up against the loads and stresses placed on them in the human body. Strength is a condemnatory factor for the material selection of knee implant.The material should have a high strength to weight ratio. The material must ensure that it can stand firm against the mechanical forces while providing durability and necessary support for the implant.
4. Elastic modulus:
The elastic modulus is used to measure the stiffness of the material along with it is also use to measure the ability to deform under certain stress. Under a specific elastic deformation range, elastic modulus is obtained when stress is divided by strain. To indicated the varying stiffness level, different material have different elastic modulus value.
5. Bio compatibility:
while selecting materials for knee implants, Bio compatibility is a crucial consideration. The material which is chosen must well-tolerate by human body, reduce the risk of adverse

reaction. With the surrounding tissues and enhances overall patient outcome, bio compatibility helps to promote successful implant.

6. Wear resistance:

Wear resistance is a vital criterion in choosing materials for knee implants, as they must endure repeated motion without degrading. Materials like cobalt-chromium alloys and ceramics are often selected for their excellent wear resistance. This characteristic helps minimize friction between components, reducing the likelihood of implant wear and ensuring long-term durability. Prioritizing wear resistance is essential to enhance the performance and longevity of knee implants, promoting patient well-being.

7. Sustainability/sustainable manufacturing process

The sustainability of knee implants encompasses various factors related to environmental impact, economic considerations, and social responsibility throughout the life cycle of the implant. Choosing materials with a lower environmental footprint, such as titanium alloys or bio compatible ceramics, can reduce the environmental impact of knee implants. Additionally, selecting materials that are durable and have a long lifespan can minimize the need for frequent replacements, thereby reducing resource consumption and waste generation.

3 Methodology

To select best sustainable material for knee implant, first design of the different parts of the total knee implant model are made. There are four main parts of knee implant model. These are: 1. Top surface of the tibia 2. End of the femur (thigh bone3. polyethylene insert 4. Stem). After assembling all the parts in Solidworks , we can obtain the total knee replacement model as shown below in figure.1.

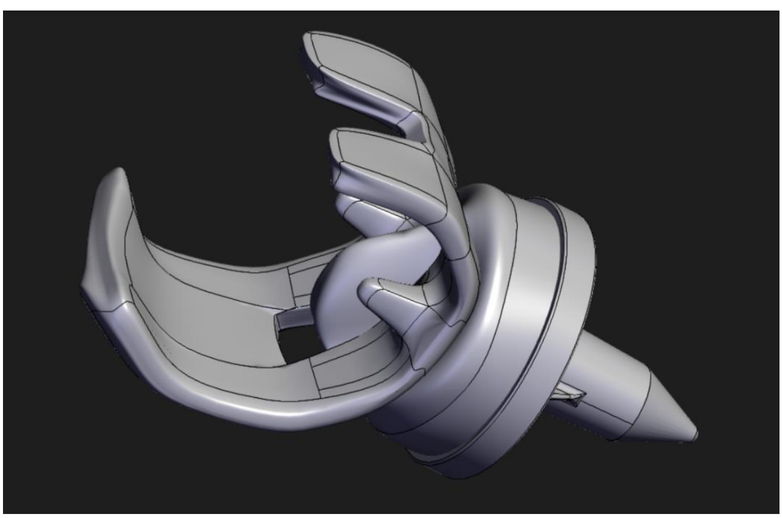

Fig. 1. Knee implant

After designing the 3D model in knee implant, the main and foremost important part is material selection. For selecting the material we will use the TOPSIS(Technique for Order of Preference by Similarity to Ideal Solution) method. TOPSIS is a multiple-criteria decision-making (MCDM) method used to determine the best alternative among a set of options based on their similarity to an ideal solution. To determine the rank of the material, we must have to determine the weight of different factor. Hence we are using Entropy method to determine the weight of different criteria.

3.1 Entropy method

Step 1.
Normalize the decision matrix.

Step 2.compute the entropy value.

$$e_j = -h \sum_{i=1}^{n} r_{ij} \ln r_{ij} \qquad j=1,2,3\ldots..n$$

Where h= 1/ln(n) , 'n' is the number of alternatives.

Step 3.compute the weight vector

$$W_j = \frac{1-e_j}{\sum_{j=1}^{n} 1-e_j} \quad , j=1,2,3,4\ldots\ldots n$$

3.2 TOPSIS Method

Step 1. calculate the Normalized matrix.

$$\bar{x}_{ij} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{n} {x_{ij}}^2}}$$

Step 2. calculate weighted normalized matrix.

$$v_{ij} = \bar{x}_{ij} \times w_j$$

Step 3. calculate the ideal best and ideal worst value.

Step 4. calculate Euclidean distance from ideal best.

$$s_i^+ = [\sum_{j=1}^{m} (v_{ij} - v_j^+)^2]^{0.5}$$

Step 5. calculate Euclidean distance from ideal worst.

$$s_i^- = [\sum_{j=1}^{m} (v_{ij} - v_j^-)^2]^{0.5}$$

Step 6. Calculate Performance Score

$$P_j = \frac{s_j^-}{s_j^+ + s_j^-}$$

Step 7. Rank them.

4 Result and discussion:

For selection of best sustainable material for knee replacements Table.1 shows list of materials and their compositions. .Then the properties like corrosion, density, tensile property, elastic modulus,elongation etc were collected from different research papers and to measure sustainability and wear resistance a scale is considered (I.e., exceptionally high=more than 0.8, very high=0.7, high=0.6 , above average= greater than 0.5 , average=0.5 , below average=less than 0.5 and low=less than 0.2 on the scale 0 to 1).The average of sustainability/ sustainable manufacturing and wear resistance scale is taken in Table.2 after interaction with around 20 no of customers those using knee implants and also 10 no of manufacturers of knee implants.Table.3 shows normalized matrix.In the second phase eweight of the materials are calculated by Entropy method and then ranking is done by TOPSIS method.

Table 1. list of materials(Farag et al.(1997), Greiner et al.(2005), Semlitsch et al.(1991), Matweb. et al.(2009))

Number for material	Name of the material	Composition
1	L316 stainless steel (annealed)	Fe balancing, 17–20% Cr,10–14% Ni, 2–4% Mo, 0.03–0.08% C, 2% Mn and 0.75% Si
2	L316 stainless steel (cold worked)	
3	Co- Cr alloys (wrought Co-Ni-Cr-Mo)	Co balancing, 19–21% Cr, 9–11% Ni, 14.6–16% W, 0.13% Mo, 0.05–0.15% C, 0.48% Si and maximum 2% Mn & 3% Fe
4	Co–Cr alloys (cast able Co–Cr–Mo)	Co balancing, 27–30% Cr, 2.5% Ni, 5–7% Mo, 0.75% Fe, 0.36% C and maximum 1% Mn & Si
5	Ti alloys(pure Ti)	0.3% Fe, 0.08% C, 0.13% O2, 0.07% N2
6	Ti alloys (Ti–6Al–4V)	Ti balancing, 5.5–6.5% Al, 3.5–4.5% V, 0.25% Fe and 0.08% C
7	Ti–6Al–7Nb (IMI-367 wrought)	Ti balancing, 5.50–6.50% Al, 60.080% C, 60.0090% H, 60.25% Fe, 6.50–7.50% Nb, 60.050% N, 60.20% O, 60.50% Ta
8	Ti–6Al–7Nb (protasul-100 hot-forged)	
9	NiTi shape memory alloy	Ni 55.0–56.0%, Ti 43.835–45.0%, C 6 0.050%, Fe 6 0.050%, O 6 0.050%, H 6 0.0050%, other 6 0.010%
10	Porous NiTi shape memory alloy	Ni–49.0 at.% Ti, 16% porosity

Table 2. Properties of materials for material selection of knee implant (the data were collected from Farag MM. et al.(1997), Greiner C et al.(2005), Semlitsch MF et al.(1991), Matweb. et al.(2009), Dsc FRSFFIMRESCBE et al.(1999), Ryhanen J et al.(1997), Zhu S et al.(2005))

	Corrosion	**Density (g/cc)**	**Tensile Strength MPa**	**Elastic modulus GPa**	**Elongation %**	**Sustainability**	**Wear resistance**
1	High	8	512	200	40	Above average	Above average
2	High	8	862	200	12	Above average	Very high
3	Very High	9.13	896	240	10-30	High	Extremely high
4	Very High	8.3	655	240	10-30	High	Extremely high
5	Exceptionally high	4.5	550	100	54	Very high	Above average
6	Exceptionally high	4.43	985	112	12	Very high	High
7	Exceptionally high	4.52	>900	105- 120	>10	Very high	High
8	Exceptionally high	4.52	1000- 1100	110	10-15	Very high	High
9	Extremely high	6.50	>1240	>48	12	Average	Exceptionally high
10	Very High	<4.3	1000	15	12	Exceptionally high	Exceptionally high

Table. 3 Selection of Decision matrix of Materials based on their properties duiring manufacturing

	Corrosion	Density (g/cc)	Tensile Strength MPa	Elastic modulus GPa	Elongation %	Sustainability	Wear resistance
1	0.665	8	512	200	40	0.590	0.590
2	0.665	8	862	200	12	0.590	0.745
3	0.745	9.13	896	240	30	0.665	0.865
4	0.745	8.3	655	240	30	0.665	0.865
5	0.955	4.5	550	100	54	0.745	0.590
6	0.955	4.43	985	112	12	0.745	0.665
7	0.955	4.52	900	120	10	0.745	0.665
8	0.955	4.52	1100	110	15	0.745	0.665
9	0.865	6.50	1240	48	12	0.500	0.955
10	0.745	4.3	1000	15	12	0.955	0.955

4.1 Entropy Method

Step 1. Normalize the decision matrix.

Table 4. Normalized matrix

Si no	Corrosion	Density (g/cc)	Tensile Strength MPa	Elastic modulus GPa	Elongation %	Sustainability	Wear resistance
1	0.665	8	512	200	40	0.59	0.59
2	0.665	8	862	200	12	0.59	0.745
3	0.745	9.13	896	240	30	0.665	0.865
4	0.745	8.3	655	240	30	0.665	0.865
5	0.955	4.5	550	100	54	0.745	0.59
6	0.955	4.43	985	112	12	0.745	0.665
7	0.955	4.52	900	120	10	0.745	0.665
8	0.955	4.52	1100	110	15	0.745	0.665
9	0.865	6.5	1240	48	12	0.5	0.955
10	0.745	4.3	1000	15	12	0.955	0.955
sum	8.25	62.2	8700	1385	227	6.945	7.56

Table.4 Weighted Normalized Matrix

si no	Corrosion	Density (g/cc)	Tensile Strength MPa	Elastic modulus GPa	Elongation %	Sustainability	Wear resistance
1	0.080606061	0.128617363	0.058850575	0.144404332	0.176211454	0.084953204	0.078042328
2	0.080606061	0.128617363	0.09908046	0.144404332	0.052863436	0.084953204	0.098544974
3	0.09030303	0.146784566	0.102988506	0.173285199	0.13215859	0.09575234	0.114417989
4	0.09030303	0.133440514	0.075287356	0.173285199	0.13215859	0.09575234	0.114417989
5	0.115757576	0.072347267	0.063218391	0.072202166	0.237885463	0.107271418	0.078042328
6	0.115757576	0.071221865	0.113218391	0.080866426	0.052863436	0.107271418	0.087962963
7	0.115757576	0.0726688 1	0.103448276	0.086642599	0.044052863	0.107271418	0.087962963
8	0.115757576	0.0726688 1	0.126436782	0.079422383	0.066079295	0.107271418	0.087962963
9	0.104848485	0.104501608	0.142528736	0.0346570 4	0.052863436	0.07199424	0.126322751
10	0.09030303	0.069131833	0.114942529	0.010830325	0.052863436	0.137508999	0.126322751

Step 2.compute the entropy value.

Step 3.compute the weight vector

Table 5. Use of entropy method for weight calculation

$\sum_{i=1}^{n} r_{ij} \ln r_{ij}$	-2.292255893	-2.257923395	-2.268292645	-2.138139337	-2.121186658	-2.288342452	-2.286713547
e_j	0.995514085	0.980603671	0.985106979	0.928582116	0.92121966	0.9938145	0.993107075
d_j= 1-$_j$	0.004485915	0.019396329	0.014893021	0.071417884	0.07878034	0.0061855	0.006892925
w_j	0.022201792	0.095996761	0.073708883	0.353463044	0.389901477	0.030613421	0.034114622

After determine the weight using entropy method, Weight of Corrosion is 0.022201792, Weight of Density is 0.095996761, Weight of Tensile Strength is 0.073708883, Weight of Elastic modulus is 0.353463044, Weight of Elongation is 0.389901477, Weight of Sustainability is 0.030613421, and Weight of Wear resistance is 0.034114622. Then TOPSIS method is used for finding based sustainable material for knee implant .

4.2 TOPSIS Method

Table. 6 to Table.9 shows steps of Topsis method to priortize best material for knee implant.
Step 1. calculate normalized matrix.

Table 6. Normalized Matrix Table for TOPSIS method

si no	Corrosion	Density (g/cc)	Tensile Strength MPa	Elastic modulus GPa	Elongation %	Sustainability	Wear resistance
1	0.080606061	0.128617363	0.058850575	0.144404332	0.176211454	0.084953204	0.078042328
2	0.080606061	0.128617363	0.09908046	0.144404332	0.052863436	0.084953204	0.098544974
3	0.09030303	0.146784566	0.102988506	0.173285199	0.13215859	0.09575234	0.114417989
4	0.09030303	0.133440514	0.075287356	0.173285199	0.13215859	0.09575234	0.114417989
5	0.115757576	0.072347267	0.063218391	0.072202166	0.237885463	0.107271418	0.078042328
6	0.115757576	0.071221865	0.113218391	0.080866426	0.052863436	0.107271418	0.087962963
7	0.115757576	0.07266881	0.103448276	0.086642599	0.044052863	0.107271418	0.087962963
8	0.115757576	0.07266881	0.126436782	0.079422383	0.066079295	0.107271418	0.087962963
9	0.104848485	0.104501608	0.142528736	0.03465704	0.052863436	0.07199424	0.126322751
10	0.09030303	0.069131833	0.114942529	0.010830325	0.052863436	0.137508999	0.126322751

Step 2. calculate weighted normalized matrix.

Table 7. Weighted Nomalized Matrix for TOPSIS method

	Beneficial Mateix	Non Beneficial Matrix	Beneficial Mateix	Non Beneficial Matrix	Beneficial Mateix	Beneficial Mateix	Beneficial Mateix
si no	Corrosion	Density	Tensile Strength	Elastic modulus	Elongation	Sustainability	Wear resistance
		(g/cc)	MPa	GPa	%		
1	0.002125613	0.001821041	4.67798E-06	0.000286468	0.002161017	0.00363948	0.003412388
2	0.000196834	0.000178991	7.58585E-07	3.26525E-05	7.96449E-05	0.000339537	0.000403086
3	0.000220513	0.000204274	7.88506E-07	3.9183E-05	0.000199112	0.000382698	0.000468013
4	0.000220513	0.000185704	5.76419E-07	3.9183E-05	0.000199112	0.000382698	0.000468013
5	0.000282671	0.000100683	4.84016E-07	1.63263E-05	0.000358402	0.000428737	0.000319223
6	0.000282671	9.91165E-05	8.66828E-07	1.82854E-05	7.96449E-05	0.000428737	0.000359802
7	0.000282671	0.00010113	7.92026E-07	1.95915E-05	6.63707E-05	0.000428737	0.000359802
8	0.000282671	0.00010113	9.68032E-07	1.79589E-05	9.95561E-05	0.000428737	0.000359802
9	0.000256032	0.000145431	1.09124E-06	7.8366E-06	7.96449E-05	0.000287743	0.000516708
10	0.000220513	9.62079E-05	8.80029E-07	2.44894E-06	7.96449E-05	0.000549589	0.000516708

Step 3. calculate the ideal best and ideal worst value.

Table 8. Ideal Solution in TOPSIS

	BM	NBM	BM	NBM	BM	BM	BM
si no	Corrosion	Density	Tensile Strength	Elastic modulus	Elongation	Sustainability	Wear resistance
		(g/cc)	MPa	GPa	%		
1	0.002125613	0.001821041	4.67798E-06	0.000286468	0.002161017	0.00363948	0.003412388
2	0.000196834	0.000178991	7.58585E-07	3.26525E-05	7.96449E-05	0.000339537	0.000403086
3	0.000220513	0.000204274	7.88506E-07	3.9183E-05	0.000199112	0.000382698	0.000468013
4	0.000220513	0.000185704	5.76419E-07	3.9183E-05	0.000199112	0.000382698	0.000468013
5	0.000282671	0.000100683	4.84016E-07	1.63263E-05	0.000358402	0.000428737	0.000319223
6	0.000282	9.91165E	8.6682	1.82854E	7.96449E	0.0004287	0.000359

	671	-05	8E-07	-05	-05	37	802
7	0.000282671	0.00010113	7.92026E-07	1.95915E-05	6.63707E-05	0.000428737	0.000359802
8	0.000282671	0.00010113	9.68032E-07	1.79589E-05	9.95561E-05	0.000428737	0.000359802
9	0.000256032	0.000145431	1.09124E-06	7.8366E-06	7.96449E-05	0.000287743	0.000516708
10	0.000220513	9.62079E-05	8.80029E-07	2.44894E-06	7.96449E-05	0.000549589	0.000516708
v+	0.002125613	9.62079E-05	4.67798E-06	2.44894E-06	0.002161017	0.00363948	0.003412388
v-	0.000196834	0.001821041	4.84016E-07	0.000286468	6.63707E-05	0.000287743	0.000319223

Step 4 &5. calculate Euclidean distance from ideal best & ideal worst.

Step 6. Calculate Performance Score

Step 6. RANK

Table 9. Ranking by TOPSIS method

Number for material	**Name of the material**	**rank**
1	L316 stainless steel (annealed)	1
2	L316 stainless steel (cold worked)	8
3	Co- Cr alloys (wrought Co-Ni-Cr-Mo)	7
4	Co–Cr alloys (cast able Co–Cr–Mo)	6
5	Ti alloys(pure Ti)	9
6	Ti alloys (Ti–6Al–4V)	4
7	Ti–6Al–7Nb (IMI-367 wrought)	5
8	Ti–6Al–7Nb (protasul-100 hot-forged)	3
9	NiTi shape memory alloy	10
10	Porous NiTi shape memory alloy	2

L316 stainless steel (annealed) is chosen to be the best material, apart from Porous NiTi shape memory alloy which is ranked second and Ti–6Al–7Nb (protasul-100 hot-forged) is ranked third on the basis of both environmental factor as well as mechanical factor. By taking the environmental factors in mind,stainless steel, cobalt-chromium alloys, and titanium alloys are generally recyclable, contributing to resource conservation and waste reduction. Among these, stainless steel and titanium alloys, especially pure titanium, are more widely recycled due to their higher market demand and established recycling processes. Titanium alloys typically have higher energy requirements for extraction and processing compared to stainless steel and cobalt-chromium alloys. Pure titanium, in particular, may have a lower environmental impact in terms of energy consumption compared to titanium alloys like Ti-6Al-4V due to simpler production processes. Bio compatibility is essential for implant materials to ensure they are compatible with the body and do not cause adverse reactions. Titanium and its alloys are known for their excellent bio compatibility, followed by cobalt-chromium alloys and stainless steel. The durability and long life span both must be taken care of for selected sustainable implants, as both titanium and cobalt-chromium alloys both are long-lasting materials and the deterioration rate is low, hence they are considered as better compared to stainless steel.

3 Conclusion

Material selection for implants like knee, leg etc is an important problem ,which researchers need to focus more on. For selection of materials, patients' experience, doctors' recommendation and design aspects must be considered together. But sustainable material selection must also consider the recyclability , energy consumption and lastly after use disposal method. Which not only reduces carbon foot prints but also helps save our ecosystem and environment. Hence, in this paper, recyclable materials like stainless steel, titanium and alloys are considered. These materials are durable , with a longer life span. So, in other ways, they may also help in proper waste management of medical waste.

4 Future scope

In the future, studies and research may be conducted so that with longevity , durability , they can perform better. During design modifications, some most important factors like wear, fatigue corrosion resistance must be taken into care of for the sustainable implant material . Some advanced technologies like 3D printing may help in-making complex designed knee implants considering all the properties. Before manufacturing of implant material, more research is essential in considering age factor of patients and the cost of manufacturing etc.

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