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ORIGINAL ARTICLE

Application of fuzzy TOPSIS method in pseudoarthrosis treatment with stem cells

Empleo de fuzzy TOPSIS en el tratamiento de seudoartrosis con células madre

Uso de TOPSIS difuso no tratamento de pseudoartrose com células-tronco

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ABSTRACT

Introduction: currently there are very few published studies concerning the effect of implantations with stem cells in post-surgical aseptic pseudoarthrosis. In addition, the traditional methods of adjuvant treatment in order to improve efficacy (anabolic steroids and bisphosphonates) represent high risks, rejection and even treatment abandonment by patients. Objective: to arrange the most influential variables for treatment with stem cells in post-surgical aseptic pseudoarthrosis in the Orthopedics and Traumatology service of the Hospital General Docente "Dr. AgostinhoNeto", Guantánamo, from January 2022 to January 2023, with the application of the TOPSIS fuzzy method. Method: a descriptive study was applied, with the application of Fuzzy Analytical Hierarchy process methods (Fuzzy AHP) and the Technique for Order of Preference by Similarity to Ideal Solution (fuzzy TOPSIS), with information gathered from the Orthopedics and Traumatology department of the aforementioned hospital. The universe of study consisted of 50 patients. The study sample included n=44. Results: it was possible to obtain the main variables involved in the stem cell treatment for pseudarthrosis, variables with great contribution in the success of implementation of such treatment, which were as follow: fracture trace, cause of pseudarthrosis, type of therapy used, time of bone consolidation and degree in bone consolidation. Conclusions: the hierarchization of the variables obtained will constitute a guide where the Orthopedics and Traumatology services of the Hospital General Docente "Dr. AgostinhoNeto", in Guantánamo municipality, will be able to influence in the efficacy of stem cell treatment for pseudarthrosis.

Keywords:pseudarthrosis; fuzzy TOPSIS; stem cells; quality of care

RESUMEN

Introducción: son muy escasos los estudios publicados sobre el efecto de infiltraciones con células madres en seudoartrosis aséptica posquirúrgicas. Asimismo, los métodos tradicionales de tratamiento coadyuvante para favorecer la consolidación (esteroides anabólicos y bifosfonatos) representan elevados riesgos, rechazo e incluso abandono del tratamiento por parte del paciente. **Objetivo:** jerarquizar las variables más influyentes para el tratamiento con células madre en la seudoartrosis aséptica posquirúrgica en el servicio de Ortopedia y Traumatología del Hospital General Docente "Dr. Agostinho Neto" del municipio de Guantánamo en el período de enero 2022 a enero 2023, con el empleo de la herramienta fuzzy TOPSIS. **Método:** se aplicó un estudio descriptivo, con el apoyo de los métodos de proceso de jerarquía analítica difusa (fuzzy AHP) y técnica para el cumplimiento de órdenes por similitud con la solución ideal difusa (fuzzy TOPSIS), con datos del departamento de Ortopedia y Traumatología del hospital antes mencionado. El universo estuvo constituido por 50 pacientes, la muestra del estudio quedó conformada por n = 44. **Resultados:** se pudieron obtener las principales variables que intervienen en un tratamiento con células madre en la seudoartrosis para garantizar el éxito en la implementación de dicho tratamiento, ellas fueron: trazo de la fractura, causa de la seudoartrosis, tipo de terapia empleada, tiempo de consolidación y grado de consolidación. **Conclusiones:**la jerarquizaciónde las variables obtenidas constituirá una guía donde los servicios de Ortopedia y Traumatología del Hospital General Docente "Dr. Agostinho Neto", del municipio de Guantánamo, podrá incidir en la efectividad del tratamiento con células madre en la seudoartrosis.

Palabras clave: seudoartrosis; fuzzy TOPSIS; células madre; calidad en la atención

RESUMO

Introdução: existem poucos estudos publicados sobre o efeito de infiltrações com células-tronco em pseudoartrose asséptica pós-cirúrgica. Da mesma forma, os métodos tradicionais de tratamento adjuvante para promover a consolidação (esteróides anabolizantes e bisfosfonatos) representam riscos elevados, rejeição e até abandono do tratamento por parte do paciente. **Objetivo:** priorizar as variáveis de maior influência para o tratamento com células-tronco na pseudoartrose asséptica pós-cirúrgica no serviço de Ortopedia e Traumatologia do Hospital General Docente "Dr. Agostinho Neto" do município de Guantánamo no período de janeiro de 2022 a janeiro de 2023, com a utilização da ferramenta fuzzy TOPSIS. **Método:** foi aplicado um estudo descritivo, com apoio dos métodos de processo hierárquico analítico fuzzy (fuzzy AHP) e da técnica de atendimento de pedidos por similaridade com a solução fuzzy ideal (fuzzy TOPSIS), com dados do Departamento de Ortopedia e Traumatologia do referido hospital. O universo foi constituído por 50 doentes, a amostra do estudo foi constituída por n=44. **Resultados:** foi possível obter as principais variáveis que intervêm num tratamento com células estaminais na pseudoartrose para garantir o sucesso na implementação do referido tratamento, elas foram eles: linha de fratura, causa da pseudoartrose, tipo de terapia utilizada, tempo de consolidação e grau de consolidação. **Conclusões:** a hierarquização das variáveis obtidas constituirá um guia onde os serviços de Ortopedia e Traumatologia do Hospital General Docente "Dr. Agostinho Neto", município de Guantánamo, poderá influenciar a eficácia do tratamento com células-tronco na pseudoartrose.

Palavras-chave:pseudoartrose; TOPSIS difuso; células mãe; qualidade do cuidado

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INTRODUCTION

The stem cell is as it were the base of the pyramid for each lineage, lineage being understood as the differentiation of functions of each cell. The epithelial (skin) cell is one lineage; the blood cell is another, and so on. Studies have shown that for the formation of each lineage there is a stem cell that created them, from which they come from.(1)

Most fractures complete all these phases and heal after orthopedic or surgical treatment, which must achieve correct alignment of the fragments and mechanical stability, the latter being an absolutely necessary condition for healing. However, with some frequency there is a significant failure rate, among which is aseptic pseudoarthrosis.(2) Loss of employment, social and economic problems frequently occur. This process is an expectant pathway for the specialist who seeks at all times procedural efficacy, especially of a non-surgical nature.(3)

The location of pseudoarthrosis has a clear incidence in the long bones and especially at the diaphyseal level; the three segments most involved in this problem: the femur, tibia and humerus.(4) It is a complication that occurs relatively frequently in fracture.(5)

There are different types of stem cells that can be used in the treatment, including bone marrow stem cells, adipose tissue stem cells and mesenchymal stem cells.(6)

On the other hand, the treatment is concerned with improving analytical techniques, integrating qualitative and quantitative evaluations, as well as a multi-criteria approach. These techniques are more complex, since they analyze more uncertainty information and, consequently, turn out to be more systematic and realistic to solve problems under multicriteria environment.

In fact, the TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) fuzzy method allows ranking and selecting the best alternative from a discrete group, which have been used in various fields where a selection problem is presented.(7)

Therefore, this research aims to rank the most influential variables for stem cell treatment in post-surgical aseptic pseudoarthrosis in the Orthopedics and Traumatology service of the General Teaching Hospital "Dr. AgostinhoNeto", in the municipality of Guantánamo in the period from January 2022 to January 2023.

METHOD

A descriptive study was performed with the support of fuzzy AHP (Analytic Hierarchy Process) fuzzy analytic hierarchy process methods and technique for order fulfillment by similarity to fuzzy ideal solution (fuzzy TOPSIS).

The universe consisted of 50 patients with a clinical diagnosis of pseudarthrosis. The study sample consisted on 44 of these who met the inclusion and exclusion criteria (presence of a previous fracture, chronic pain in the affected area, limited mobility, a mass of fibrous or bony tissue and radiographs);with regard to exclusion, fractures that had not been adequately treated or immobilized, infections in the affected area, autoimmune diseases and metabolic bone diseases were taken into account, according to the database consulted.

Two methods from the Multiple-criteria Decision Making (MCDM) family were applied, where multicriteria decision support methods have the ability to help decision-makers "evaluate alternatives".[8] According to Ridha,[9] MCDM methods are based on "multi-objective optimization", which increases the dynamism of the decision-making requirements.[10]

Fuzzy AHP (FAHP)

The Fuzzy Analytic Hierarchical Analytic Process (FAHP), taking into account a nine-point scale and five triangular fuzzy numbers($\tilde{1}, \tilde{3}, \tilde{5}, \tilde{7}, \tilde{9}$), with the corresponding membership functions defined in Table 1, are used both to indicate the relative strength of each pair of elements in the same hierarchy and to establish the fuzzy decision matrix for performance evaluation.

Table 1 Definition and relevance function of fuzzy scaling

Intensity of importance	Fuzzy number	Definition	Member function
1	$\tilde{1}$	Equal importance (IE)	(1, 1, 2)
3	$\tilde{3}$	Moderate importance (MI)	(2, 3, 4)
5	$\tilde{5}$	Strong importance (SIM)	(4, 5, 6)
7	$\tilde{7}$	Very important (VSI)	(6, 7, 8)
9	$\tilde{9}$	Extremely important (EMI)	(8, 9, 10)

This study uses the FAHP[11] method and is used to determine the weightings of the evaluation criteria.

For the application of this methodology it is necessary that both criteria and alternatives can be structured hierarchically so that the first level of the hierarchy corresponds to the general objective of the problem, the second to the criteria and the third to the alternatives.[14] As Dautov states,[15] hierarchical ordering allows the decision-maker to have a "vision of the system as a whole and of its components, as well as of the interactions of these components and the impacts they have on the system".[16]

From the literature review, it was observed that three articles integrate FAHP and FTOPSIS. There is no doubt that the FAHP-FTOPSIS combination can help the decision-maker build a solid basis for evaluation. However, the existence of fuzzy information may have an imperceptible impact on accuracy, providing room for future improvements.[16]

Fuzzy TOPSIS (FTOPSIS)

The steps of Parveen[16] were taken into account and subsequently the FTOPSIS approach was applied on the data obtained. To assign the scores on the fuzzy scale in relation to the evaluations made by the respondents, a triangular function was assigned, where each score is represented by three numbers. Table 2 and Table 3 illustrate the scores assigned in this case.

Table 2 Triangular Fuzzy Scale Score

Score	Diffuse Triangular Scale		
Not important (PT1)	0	0	0,1
Slightly important (PT2)	0	0,1	0,3
Slightly important (WP3)	0,1	0,3	0,5
Neutral (WP4)	0,3	0,5	0,7
Moderately important (WP5)	0,5	0,7	0,9
Very important (WP6)	0,7	0,9	1,0
Extremely important (PT7)	0,9	1,0	1,0

Table 3 Fuzzy scale of experience levels

Level of Experience	**Triangular Scale Fuzzy**		
Level 1 (N1)	0,00	0,00	0,50
Level 2 (N2)	0,00	0,50	0,75
Level 3 (N3)	0,50	0,75	1,00
Level 4 (N4)	0,75	1,00	1,00

As stated by Parveen,[16] once the data have been processed using the triangular fuzzy scale, the appropriate calculations are made through the following stages:

Stage1: Structuring of the matrix with the values obtained (reported by the respondents) for each of the variables and of the matrix with the levels of experience.
Stage 2: Normalization of the matrix of the values obtained for the variables to obtain the matrix of the scores.
Stage 3: From the weightings made between the values obtained for the response variables and the levels of experience of the respondents, a new matrix was generated, established by product/multiplication between the fuzzy values obtained for the response variables in normalized form and the fuzzy levels of experience of the respondents also in normalized form.
Stage 4: Through the weighted and normalized fuzzy matrix obtained, the distance between each of the elements of the positive and negative ideal solutions was calculated.
Step 5: The calculation of the total distance referred to each of the alternatives in relation to the ideal solutions (positive and negative), could be performed with the sum of the partial distances found.
Stage 6: Finally, it was possible to calculate the proximity coefficient (CCi) for each of the variables analyzed. In this case, the variables for the treatment were ordered in descending order. Thus, those that are among the first in the ranking will be considered as the main ones evaluated by the specialists.

RESULTS

This section briefly presents the results of the identification of variables to robust stem cell therapy in postsurgical aseptic pseudarthrosis in the Orthopedics and Traumatology service.

FAHP was used to calculate weights for the initially listed levels of expertise (N1, N2, N3, and N4) according to Tables 2 and 3 (from the previous section) for each expert selected in this study. A comparison was made among the experts with respect to the level of expertise.

We proceeded to calculate the fuzzy weights for each expert, where the set of fuzzy weights is important not only for reasons of fairness and easy interpretation, but also because it is necessary to arrive at a unique solution for some methods as shown in Table 4.

Table 4 Geometric mean of the fuzzy comparison value($\tilde{r}1$) and distribution of the fuzzy weights

Geometric fuzzy mean				(Fuzzy weight)				
CRI		r_i			*Wi*			*Rank*
E1	0,000	0,509	5	0,000	0,096	0,139	0,000	5
E2	0,669	1,071	4	0,065	0,112	0,146	0,067	4
E3	0,721	1,053	2	0,072	0,115	0,165	0,093	2
E4	0,760	1,000	3	0,073	0,110	0,164	0,095	3
E5	1,000	1,000	1	0,075	0,113	0,169	0,092	1

As a result of the above, the order of importance of the experts is clearly shown, taking into account the pairwise comparisons, where a preference scale was used.

After obtaining the weightings of each researcher, a matrix was constructed where the experts are related according to the variables that drive the robustness of the treatment, based on a checklist. The prioritization and selection of the most feasible variables were carried out with the application of FTOPSIS, with the R Studio tool and the use of the FMCDM package.

The FTOPSIS model, once the weights and the comparison matrix of the treatment variables were obtained to identify the degree of importance, the model was applied using R Studio, as shown in Table 5.

Table 5 Main variable FTOPSIS method

Variables	Code	R.1	R.2	R.3	Def_R	Ranking
Fracture Tracing	V9	0.187	0.713	18.95	0.800	1
Causes of pseudarthrosis	V10	0.283	0.828	11.35	0.747	3
Type of therapy used	V2	0.272	0.618	18.70	0.714	4
Time of consolidation	V4	0.361	0.815	14.60	0.692	2
Degree of healing	V7	0.220	0.547	17.79	0.676	5

In the application of the FTOPSIS method, an increasing order was followed, and an analysis of the 5 most influential of a total of 11 variables was carried out, as shown below: V9 > V4 > V10..., among others.

DISCUSSION

It is important to keep in mind that decision making in stem cell therapy for postsurgical aseptic pseudarthrosis in the orthopedic and trauma service should be an ongoing and adaptive process, adjusting as new information is obtained and circumstances change. In addition, it is essential to involve stakeholders and the community throughout the process to ensure that patient needs and concerns are addressed and optimal outcomes are achieved.

For this reason, the results were satisfactory, that is, the main objective of the present study was fulfilled, in proposing variables to strengthen the proposed treatment with the evaluation of the FTOPSIS method; the variables taken into account were fracture trace, time of consolidation, causes of pseudarthrosis, type of therapy used and degree of consolidation.

CONCLUSIONS

Thus, it is concluded that the identification of variables for treatment based on multiple criteria, such as efficacy, safety, cost and quality of life of the patient, were the best alternatives.

The FTOPSIS method proves to be an effective tool to facilitate the treatment station that produces high yields, consequently, an improvement in the analysis process.

Decision making is complicated, a robust treatment should be formed early in order to improve the patient's quality of life, the variables obtained will allow being a guide where the Orthopedics and Traumatology services of the General Teaching Hospital of the municipality of Guantanamo can influence the effectiveness of the process towards the treatment of the patients attended.

REFERENCES

1. Si F, Le Treut G, Sauls JT, Vadia S, Levin PA, Jun S. Mechanistic Origin of Cell-Size Control and Homeostasis in Bacteria. Current Biology [Internet].2019 Jun [cited 16 Feb 2023]; 29(11):1760-1770.e7. DOI: https://doi.org/10.1016/j.cub.2019.04.062
2. Kostic I, Mitkovic M, Mitkovic M. The diaphyseal aseptic tibialnonunions after failed previous treatment options managed with the reamed intramedullary locking nail. J ClinOrthop Trauma [Internet]. 2019 Jan[cited 16 Feb 2023]; 10(1):182-90. DOI: https://doi.org/10.1016/j.jcot.2017.08.006
3. Romero-Soto M. Efecto de las ortesis plantares sobre las presiones plantares y tensión muscular en corredores amateurs tras 8 semanas de uso: un ensayo clínico aleatorizado [Tesis Doctoral]. España:

Universidade da Coruña; 2022 [cited 16 Feb 2023]; Available at: https://ruc.udc.es/dspace/handle/2183/31221

4. Minervini F, Peek J, van Veelen NM, Kestenholz PB, Kremo V, Leiser A, *et al*. Nonunion of traumatic rib fractures: a suitable indication for surgery? Eur J Trauma EmergSurg [Internet]. 2022 Aug [cited 16 Feb 2023]; 48(4):3165-9. Available at: https://link.springer.com/article/10.1007/s00068-021-01865-z
5. Velázquez-Moreno JD, Casiano-Guerrero G. Algoritmo del tratamiento de la seudoartrosisdiafisaria. ActaOrtopMex [Internet]. 2019 Ene-Feb [cited 16 Feb 2023];33(1):50-7. Available at: https://www.medigraphic.com/pdfs/ortope/or-2019/or191l.pdf
6. López Fonseca MP. Uso autólogo de células madre mesenquimales aisladas de medula ósea para el tratamiento de lesiones osteocontrales Revisión de protocolos y métodos de criopreservación [Tesis]. Pontificia Universidad Javeriana; 2015 [cited 29 Abr 2023]; Available at: http://repository.javeriana.edu.co/handle/10554/16671
7. Muñoz-Medina B, Ordóñez J, Romana MG, Lara-Galera A. Typology Selection of Retaining Walls Based on Multicriteria Decision-Making Methods. ApplSci [Internet]. 2021 Jan [cited 29 Abr 2023]; 11(4):1457. DOI: https://doi.org/10.3390/app11041457
8. Akhanova G, Nadeem A, Kim JR, Azhar S. A multi-criteria decision-making framework for building sustainability assessment in Kazakhstan.Sustainable Cities Soc [Internet]. 2020 Jan [cited 29 Abr 2023]; 52:101842. DOI: https://doi.org/10.1016/j.scs.2019.101842
9. Ridha HM, Gomes C, Hizam H, Ahmadipour M, Heidari AA, Chen H. Multi-objective optimization and multi-criteria decision-making methods for optimal design of standalone photovoltaic system: A comprehensive review. Renewable and Sustainable Ener Rev [Internet]. 2021 Jan [cited 29 Abr 2023]; 135:110202. Available at: https://ideas.repec.org/a/eee/rensus/v135y2021ics1364032120304925.html
10. Pidgeon A, Dawood N. Bridging the gap between theory and practice for adopting meaningful collaborative BIM processes in infrastructure projects, utilising multi-criteria decision making (MCDM). ITcon [Internet]. 2021 Nov [cited 29 Abr 2023]; 26:783-811. DOI: https://doi.org/10.36680/j.itcon.2021.043
11. NazimMohd, Wali Mohammad C, SadiqMohd. A comparison between fuzzy AHP and fuzzy TOPSIS methods to software requirements selection.Alexandria Engineering J [Internet]. 2022 Dec [cited 29 Abr 2023]; 61(12):10851-70. DOI: https://doi.org/10.1016/j.aej.2022.04.005
12. Marins C. O uso do método de análise hierárquica (ahp) na tomada de decisões gerenciais- um estudo de caso. PesqOper Gest Conh[Internet]. 2009 [cited 29 Abr 2023]; 11:1778-1788.Available at: http://www2.ic.uff.br/~emitacc/AMD/Artigo%204.pdf
13. Dautov R, Distefano S, Buyya R. Hierarchical data fusion for Smart Healthcare. J Big Data [Internet].2019 Feb [cited 29 Abr 2023]; 6(1):19. Available at: https://journalofbigdata.springeropen.com/articles/10.1186/s40537-019-0183-6
14. Velmurugan K, Saravanasankar S, Venkumar P, Sudhakarapandian R, Bona GD. Hybrid fuzzy AHP-TOPSIS framework on human error factor analysis: Implications to developing optimal maintenance management system in the SMEs. Sustainable Futures. 2022 Jan; 4:100087.

15. Lee PC, Lo TP, Tian MY, Long D. An Efficient Design Support System based on Automatic Rule Checking and Case-based Reasoning. KSCE J CivEng [Internet]. 2019 May. [cited 29 Abr 2023]; 23(5):1952-62. Available at: https://link.springer.com/article/10.1007/s12205-019-1750-2
16. Parveen N, Kamble PN. An extension of TOPSIS for group decision making in intuitionistic fuzzy environment.MathemFoundComp[Internet]. 2021 [cited 29 Abr 2023];4(1):61-71. DOI: https://doi.org/10.3934/mfc.2021002

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