



## ASSESSMENT OF THE KEY DETERMINANTS FOR THE LONG-TERM SUCCESS OF DENTAL IMPLANTS: AN APPLICATION OF THE MICMAC TECHNIQUE.

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### Abstract:

The present investigation used a mixed methodological strategy that combined qualitative and quantitative approaches. A review of the existing literature was carried out, and interviews with practitioners in the field were conducted to gather information on key factors in the practice of aesthetic dentistry. Next, the MICMAC technique (Applied Multiplication Cross Impact Matrices for a Classification) was applied to identify the relationships and dynamic structure between the variables. The results showed that the key factors in the long-term success of dental implants were adherence to oral care and maintenance, bone quality and quantity, maintenance and replacement costs, and implant design and surface. These findings provide a solid foundation for understanding key factors in the practice of aesthetic dentistry and may contribute to the improvement of the planning and treatment of dental implants to achieve successful and lasting results.

**Key words:** aesthetic dentistry, dental implants, key factors, bone quality, adherence to oral care.

### Introduction

In recent years, dental implants have become an increasingly popular and effective solution to replace missing teeth (Rosenstein & Dym, 2020). These devices offer a durable alternative to removable dentures and allow patients to regain oral function and esthetics almost naturally (Jiang, et al, 2020). However, although dental implants have proven to be highly successful in many cases, there are key

factors that influence their long-term success and that must be comprehensively evaluated and considered (López-Píriz, et al., 2019). The placement of a dental implant is not limited solely to the surgical procedure itself. It is a complex process that covers various stages, from the initial evaluation of the patient to post-surgery follow-up. Each of these stages involves a set of determining factors that can influence the final result and the durability of the implant.

The quality of the bone is one of the fundamental factors that determine the success of dental implants. Adequate healthy bone provides a solid foundation for the implant and facilitates its integration with surrounding tissues (Zhao, et al., 2022). Additionally, proper adherence to oral care practices, such as hygiene and regular dental visits, is crucial to avoiding complications and maintaining long-term oral health. The design of the implant and the materials used also play a vital role in long-term success (Liu, Rath, Tingart, & Eschweiler, 2020). Technological advances in this field have allowed the development of dental implants with improved biomechanical and aesthetic characteristics. The choice of the appropriate design, the type of material, and the compatibility with the surrounding tissues are essential aspects that influence the survival and long-term performance of the implant (Montero, 2021).

In addition, the costs associated with the maintenance and care of dental implants must be considered (Coli & Jemt, 2021). This includes regular follow-up visits, professional cleanings, and any possible repairs or replacements over time. Proper financial planning and understanding of the economic implications of dental implants are crucial to ensure long-term success and patient satisfaction (Patel, 2019). These and other factors are important to the long-term success of dental implants. To comprehensively assess and understand the interrelationship of these key factors, the application of the MICMAC technique (Multiplicative Cross Impact Matrix Applied to a Classification) was proposed. This analytical technique makes it possible to identify and classify the fundamental determinants in the dental implant placement process, as well as to understand how they interact and influence each other.

By using the MICMAC technique, a clearer and more detailed vision of the interdependence between factors is obtained, as well as their level of influence. This can be verified with the different applications in research, for example, in (Barati, Azadi, Dehghani, Lebailly, & Qafori, 2019) MICMAC was used to determine the classifications of agricultural strategic variables to provide instructions for the development of the agricultural system, where the results show that the strategic variables had different types of influence and the direct, indirect and potential dependencies did not have the same importance.

Therefore, the application of this technique will allow the development of more effective and personalized strategies, adapted to the specific needs of each patient, providing a greater guarantee of success and a satisfactory experience in treatment with dental implants. In summary, this article aims to provide a comprehensive assessment of the key determinants for the long-term success of dental implants, using the MICMAC technique as an analysis tool. The findings and conclusions presented here are expected to serve as a guide for dental professionals, contributing to a continuous improvement in the quality of implant procedures and patient satisfaction. Understanding and evaluating these key determinants will enable dental professionals to make more informed decisions, personalize treatments, and optimize the long-term results of dental implants, benefiting the health and well-being of patients.

## **Methodology**

In this research, a mixed methodological strategy was used that combined qualitative and quantitative approaches (Sampieri, 2018). The research design was non-experimental, cross-sectional, correlational, and descriptive. In order to gather information on the key factors in the practice of esthetic dentistry, a review of the existing literature was carried out and interviews were conducted with professionals in the field. Next, a structural analysis was carried out to identify the relationships and the dynamic structure between the variables, using a qualitative approach according to Herrera (2017). The technique used for this analysis was the MICMAC technique (Multiplication Cross

Impact Matrices Applied for a Classification), which combines quantitative and qualitative methods to identify key factors through a square matrix. This matrix is classified in a four-quadrant plane: key, autonomous, determinant, and result factors (Arango & Cuevas, 2014). The different phases of the MICMAC technique are described below.

**Phase I: Definition of the list of variables or factors**

In this phase, the variables that are part of the system are identified and a list of internal and external variables to the system is created. A detailed description of each variable is provided to facilitate the analysis, the location in the plane, and the description of the relationships between them.

**Phase II: Description of the relationships between variables or factors**

In this phase, questions are asked to determine if there is a direct influence relationship between variables i and j. A score of 0 is assigned if there is no direct relationship, and it is evaluated whether the relationship is weak (1), medium (2), strong (3), or potential (4) if it exists. These responses are used to complete the direct influence matrix, which is essential for the structural analysis of system variables.

**Phase III: Classification of variables or factors**

In this phase, the aim is to identify and classify the key variables of the system according to their direct, indirect, and potential influence. This classification makes it possible to determine the relevance of certain variables and highlight the role of indirect variables. The results are presented in a plane of four quadrants: Quadrant I (Conflict Zone) for the key variables, Quadrant II (Power Zone) for the determinant variables, Quadrant III (Autonomous Zone) for the autonomous variables and Quadrant IV (Zone output) for the result variables.

The results obtained from the application of this methodology are presented below in the results section.

## Results

The literature review revealed a series of determinants that influence the long-term success of dental implants, which were classified into different categories, namely: clinical factors, psychosocial factors, economic factors, and organizational factors. In the category of clinical factors, three subfactors were identified: Bone quality and quantity, Implant surface design, and Surgical technique and implant placement. In the category of psychosocial factors, two subfactors were identified: Expectations and attitude of the patient and Adherence to oral care and maintenance. In the category of economic factors, two subfactors were identified: Financial accessibility and Maintenance and replacement costs. In the category of organizational factors, two subfactors were identified: Quality of dental care and Follow-up protocols and management of complications. These factors or variables were coded in a table to subsequently apply phase I of the MICMAC technique.

Table 1 has four columns: the number of the factor, the code or short name of the factor, the full name of the factor, and its description. For example, the first row of the table corresponds to factor number one (1), whose short name is BQQ, which stands for Bone Quality and Quantity. The description of this factor is: "Bone density and the availability of sufficient bone have been identified as critical factors for the long-term success of dental implants". In this way, the table can be interpreted.

**Table 1.** Selected factors to apply MICMAC.

#	Code	Factor	Description
1	BQQ	Bone Quality and Quantity	Bone density and the availability of sufficient bone have been identified as critical factors for the long-term success of dental implants.
2	DSI	Design and surface of the implant	The shape and texture of dental implants were also considered important determinants of their long-term success.

3	STIP	Surgical technique and implant placement	The skill and experience of the dental surgeon in proper implant placement played a crucial role in the long-term results.
4	EAP	Expectations and attitude of the patient	Realistic expectations and a positive attitude on the part of the patient were correlated with better long-term outcomes.
5	OCAM	Oral care adherence and maintenance	Patient compliance with oral care instructions and regular maintenance visits were key factors in the sustained success of dental implants.
6	FA	Financial accessibility	The availability of financial resources and access to insurance coverage or financing plans influenced the ability of patients to receive and maintain dental implants in the long term..
7	MRC	Maintenance and replacement costs	Costs associated with long-term maintenance of dental implants, including possible component replacements, were considered key determinants of sustained success.
8	DSQ	Dental service quality	The quality and experience of the dental team involved in the treatment and follow-up of dental implants influenced the long-term results.
9	PFMC	Protocols for follow-up and management of complications	The implementation of adequate protocols for the follow-up of dental implants and the management of possible complications contributed to long-term success.

After creating the list of variables related to the long-term success of dental implants, a joint evaluation was carried out with a group of experts to analyze the influence and dependency interactions between each of the variables. This process was carried out using a square matrix, which corresponds to Phase II of the MICMAC technique. Figure 1 presents the matrix that shows the direct relationships of influence and dependency, which was completed with the values obtained through the joint reflection of the experts. In the figure, the first row corresponds to the Bone Quality and Quantity (BQQ) variable. For example, it can be seen that the direct influence/dependence relationship between BQQ and itself is zero (0), while the relationship with the variable Design and surface of the implant (DSI) is moderate (2), which suggests that there is a significant connection between the quality and quantity of bone and the design and surface of dental implants.

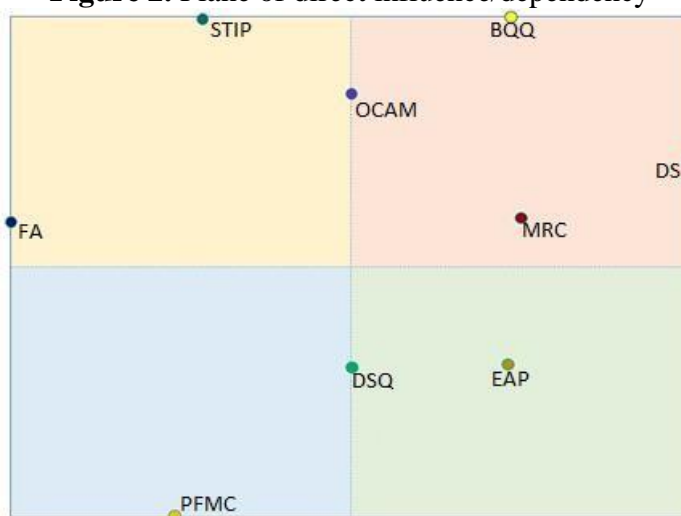
With the Surgical technique and implant placement (STIP) variable being strong (3), this implies that the quality and quantity of bone greatly influence the surgical technique and placement of dental implants. With the variable Expectations and attitude of the patient (EAP) being weak (1), this suggests that the quality and quantity of bone have a limited influence on the expectations and attitudes of patients. And with the variable Oral care adherence and maintenance (OCAM) it is moderate (2), which implies that the quality and quantity of the bone can affect the way in which patients follow the oral care and maintenance of dental implants.

**Figure 1.** Matrix of direct influence/dependence

	BQQ	DSI	STIP	EAP	OCAM	FA	MRC	DSQ	PFMC
BQQ	0	2	3	1	2	1	3	1	1
DSI	1	0	2	3	1	1	1	3	2
STIP	3	1	0	2	3	2	3	2	1
EAP	2	3	1	0	1	3	2	1	2
OCAM	1	2	3	2	0	1	1	2	3
FA	2	1	2	1	2	0	3	1	1
MRC	3	1	3	2	1	2	0	3	2
DSQ	1	3	2	1	2	1	3	0	1
PFMC	1	2	1	2	3	1	2	1	0

After completing the relationships in the direct influence/dependence matrix, the classification of the variables was carried out. This classification is visually represented in a plane of direct influence/dependence, as shown in Figure 2. The analysis revealed the existence of four key variables located in quadrant I: Oral Care Adherence and Maintenance (OCAM), bone Quality and quantity (BQQ), Maintenance and replacement costs (MRC), and Design and surface of the implant (DSI). In quadrant II, two variables were found, Surgical technique and implant placement (STIP), and Financial accessibility (FA), which were classified as determinants. In quadrant III, a variable was identified: Protocols for follow-up and management of complications (PFMC). And finally, in quadrant IV the variables Dental service quality (DSQ), and Expectations and attitude of the patient (EAP) were located.

**Figure 2.** Plane of direct influence/dependency



The results of the classification of variables using the direct influence matrix are shown below, which are described in detail in Table 2.

**Table 2.** Classification of variables by indirect dependency/influences

Type de Variable	Variable	Code
<b>Key, strategic or challenge variables</b>	Oral care adherence and maintenance	OCAM
	Bone Quality and Quantity	BQQ
	Maintenance and replacement costs	MRC
	Design and surface of the implant	DSI
<b>Determinant or influential variables</b>	Surgical technique and implant placement	STIP
	Financial accessibility	FA

<b>Autonomous or excluded variables</b>	Protocols for follow-up and management of complications	PFMC
<b>Dependent or result variables</b>	Dental service quality	DSQ
	Expectations and attitude of the patient	EAP

In principle, the variable Adherence to oral care and maintenance is a key variable in evaluating the long-term success of dental implants, since it contributes to preventing complications, maintaining periodontal health, controlling plaque bacteria, and promoting education and patient awareness. Regarding the variable bone quality and quantity, it was key in the evaluation of the long-term success of dental implants, due to its influence on implant stability, bone healing, long-term survival, and treatment planning. An adequate evaluation and consideration of these variables are essential to achieve successful and lasting results in oral rehabilitation with dental implants.

Regarding the variable Maintenance and replacement costs, it is a key variable in the evaluation of the long-term success of dental implants due to its impact on the economic sustainability of the treatment, the need to maintain adequate preventive care, the possibility of replacing components and its influence on the quality of life of the patient. It is essential to consider these costs to make informed decisions and ensure the long-term success of dental implants. For its part, the last variable that was key in the evaluation of the long-term success of the implants was the Design and surface of the dental implant, this is so due to its influence on osseointegration, load distribution, primary stability, biological compatibility, and ease of clinical handling. Proper design and surface are critical to achieving strong osseointegration and successful long-term implant function.

Regarding the determinant variables, one of the resulting ones was the Surgical technique and implant placement, this is so because this variable directly influences the long-term success rate of dental implants. An adequate technique, carried out by an experienced professional and following the appropriate protocols, increases the chances of obtaining positive and lasting results in terms of functionality, aesthetics, and oral health. The other variable that was decisive in the evaluation of the long-term success of dental implants was Financial accessibility. This is a determinant variable because it influences the ability of patients to access treatment, cover associated costs, use materials and prostheses quality, receive proper care and maintenance, and deal with possible complications and additional treatments.

On the other hand, the only variable that turned out to be autonomous was Protocols for follow-up and management of complications. This is so because this variable has a significant influence on other variables in the study and is independent of the other variables analyzed. These protocols play a crucial role in the early detection and proper treatment of complications, contributing to the long-term success of dental implants.

Regarding the result variables, Dental service quality turned out to be a result variable in the evaluation of the long-term success of dental implants, because it reflects the overall excellence and satisfaction concerning the dental services provided. This variable encompasses the patient's experience, the clinical results, and the global evaluation of the treatment, being an important indicator to determine the long-term success of dental implants. Finally, the other variable that was considered as a result variable was Expectations and attitude of the patient. This is so, because it reflects the patient's perception and attitude towards treatment with dental implants, and can influence satisfaction, adherence to treatment, and perception of success. This variable is important to assess the subjective impact and patient experience in relation to the long-term success of dental implants.

## Discussions

In relation to the key factor Oral care adherence and maintenance, the results agree with Caffesse & Echeverría (2019), where maintenance care for teeth and implants is carefully evaluated for long-term therapeutic success and it is noted that good adherence to these practices is crucial to the longevity and success of dental implants. Regarding the Bone Quality and Quantity factor, the results in Ahmed, Crespi, & Romanos (2013) confirm that bone quality and quantity can significantly influence primary

stability and the overall success rate of dental implants. Likewise, Sharka, Abed, & Hector (2019) state that good-quality bone provides solid support for the implant, which helps prevent the loosening or failure of the implant.

Regarding the factor Maintenance and replacement costs, according to Ghiasi, Petrén, Chrcanovic, & Larsson (2022), the type of maintenance could affect long-term costs, although the cost of treatment increases with the number of implants, which is complemented by this research given that the cost could also be affected if it is necessary to replace implants with significant degrees of wear. These replacements may imply additional costs that must be considered when evaluating the long-term success of the implants. Furthermore, if the entire implant needs to be replaced, the costs can be significant and affect the economic viability of the treatment.

Regarding the factor Design and surface of the implant, Steigenga, Al-Shammari, Nociti, Misch, & Wang (2003) found in their research that there is no optimal design criterion. However, implants can be designed to maximize strength, interfacial stability, and load transfer through the use of different materials, surfaces, and thread designs. For their part, Vandeweghe, Cosyn, Thevissen, Teerlinck, & De Bruyn (2012), highlight that bone remodeling is affected by the design of the implant. A suitable design and an optimized surface can help distribute forces evenly over the implant and surrounding bone, minimizing stress on the bone and reducing the risk of long-term complications such as peri-implant bone loss.

In reference to the factor Surgical technique and implant placement: the results agree with Siebers, Gehrke, & Schliephake (2010), stating that the surgical technique and dental implant placement are decisive since its correct execution has a direct impact on the implant stability, osseointegration and the final result of dental implant treatment. About Financial accessibility: according to Sharka, Abed, & Hector (2019), this factor is considered essential in the long-term success of dental implants due to its impact on the performance of the treatment, the quality of the materials used, the follow-up and long-term care, as well as treatment of possible complications. It is essential to consider financial accessibility as an integral part of the overall evaluation of the success of dental implants.

Regarding the factor Protocols for follow-up and management of complications, Yao, Tang, Gao, McGrath, & Mattheos (2014), explain that the application of protocols for follow-up and management of complications must be coherent and systematic to ensure early detection and adequate management of any complication that may arise.

Regarding the factor Dental service quality, Afrashtehfar, Assery, & Bryant (2020) highlight that as a result variable, reflects the final impact of other variables evaluated on the long-term success of dental implants. The quality of dental service influences the results obtained, is evaluated from the patient's perspective, and can be measured by compliance with established quality standards. For this reason, it is a crucial factor that must be taken into account when evaluating the long-term success of dental implants.

Finally, regarding the variable Expectations and attitude of the patient, Yao, Tang, Gao, McGrath, & Mattheos (2014), state that expectations and attitude can influence patient satisfaction, perception of treatment success, adherence to treatment and aftercare, as well as the quality of life-related to oral health. For this reason, it is important to consider the expectations and attitude of the patient when evaluating the long-term success of dental implants.

## **Conclusions**

The results of this research allow concluding the following:

The evaluation of the key determinants for the long-term success of dental implants is crucial to achieving successful and lasting results in oral rehabilitation. The results reveal several variables that play a fundamental role in this process. The variable Oral care adherence and maintenance stands out as key since it contributes to preventing complications, maintaining periodontal health, among other

aspects. On the other hand, Bone Quality and Quantity also turn out to be key because it influences the stability of the implant, bone healing, and treatment planning. Careful evaluation and proper consideration of bone quality and quantity are critical to achieving successful and lasting results in oral rehabilitation with dental implants.

Maintenance and replacement costs are another key factor to consider. It is important to consider the costs and make informed decisions to ensure long-term success. On the other hand, the design and surface of the dental implant also play a significant role in long-term success because they affect osseointegration, load distribution, and primary stability of the implant. Proper design and surface are critical to achieving strong osseointegration and successful long-term implant function.

By considering the determinants obtained in the results and addressing them comprehensively, optimal and lasting results can be achieved in oral rehabilitation with dental implants. However, some limitations must be taken into account, among them that the MICMAC technique can provide valuable information about the relationships between the determinants, but it can also present limitations of its own, for example, the input data and the assumptions made during the analysis.

On the other hand, there may be limitations in the evaluation of long-term success, since the evaluation of the long-term success of dental implants can be complex and subject to multiple factors. Lack of long-term follow-up, lack of consensus on success criteria, or lack of complete data may be limitations in assessing long-term success. It is important to keep these limitations in mind when interpreting the results of any study and to recognize that additional research and additional methodological approaches may be needed to obtain a more complete and accurate picture of the key determinants for the long-term success of dental implants.

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