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A Multi-Criteria Framework for Comparing Dental Implant Technologies: A 9-Field Decision Matrix Approach

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Abstract

Introduction: The selection of dental implant systems is frequently guided by clinician experience and practical considerations rather than by standardized comparative frameworks. This study aims to develop and implement a multi-criteria framework utilizing a 9-field frequency–severity matrix to systematically compare dental implant technologies from both provider and patient perspectives.

Methods: This conceptual methodological study employed a 3×3 frequency–severity matrix adapted from risk assessment models. Two implant technologies, standard osseointegrated implants (SOI) and Corticobasal® implants (CBI®), were systematically compared. Six provider-related domains including biological and mechanical complications, surgical requirements, corrective interventions, supporting evidence, and treatment flexibility as well as ten patient-centered domains including healing phases, augmentation burden, cost, risk, maintenance, esthetics, and retreatment complexity were assessed. Parameters were qualitatively positioned within the matrix based on their relative frequency and severity.

Results: CBI® were consistently categorized in lower frequency severity levels across most domains, including peri-implant complications, mechanical failures, and surgical burden. In contrast, SOI were more frequently associated with moderate to high complication risks, greater treatment complexity, and increased maintenance demands. From the patient perspective, CBI® were linked to shorter treatment durations, the absence of unloaded healing phases, reduced augmentation needs, and lower overall costs. Economic comparisons indicated decreased chair time, fewer appointments, and enhanced efficiency per treatment hour with CBI®.

Conclusion: The 9-field matrix serves as a structured tool for the multi-dimensional comparison of implant technologies. When evaluated across combined clinical and patient-centered parameters, CBI® consistently exhibit clearly a much lower risk and treatment burden compared to SOI, thereby facilitating more transparent and evidence-informed decision-making.

Introduction

Dental implant therapy has become a standard treatment option for replacing missing teeth and restoring oral function, esthetics, and quality of life. Over the last few decades, implant dentistry has expanded rapidly, and clinicians now have access to a wide range of implant designs, surface technologies, and surgical protocols[1]. Despite this progress, the choice between different implant systems is still often based on individual experience, brand familiarity, cost, and available training rather than on a standardized decision-making method[2].

Osseointegration is presently the foundation of conventional implant therapy and has been widely studied in the literature[3,4]. However, the long-term success of implant treatment depends not only on the biological integration of the implant, but also on the prosthetic design, maintenance requirements, surgical complexity, and patient-related factors such as bone availability, treatment time, and willingness to accept additional procedures. Reviews on osseointegration have emphasized that implant characteristics, bone quality, host conditions, and loading protocols can all influence treatment outcomes[3,5]. However, numerous published studies are conducted under controlled conditions and frequently involve selected patient populations, which may restrict their generalizability to routine clinical practice. Consequently, real-world variability, including complex cases and patients who may not meet stringent inclusion criteria, are not consistently represented.

At the same time, peri-implant diseases have become an important and increasing challenge in implant dentistry[6]. Peri-implantitis is now recognized as a clinically relevant complication that may affect implant survival and long-term maintenance, and systematic reviews show that treatment outcomes remain variable even after surgical intervention. A review of re-osseointegration after peri-implantitis treatment also showed that no single decontamination method is clearly sufficient, which reflects the complexity of managing implant complications once they occur. For this reason, clinicians increasingly need to consider not only initial implant stability, but also the long-term biological and mechanical behavior of the selected implant system[7].

No universally predictable or consistently effective treatment protocol is currently available[7].

Another important issue in implant planning is patient acceptance of treatment. Studies on patient preferences have shown that many patients are reluctant to undergo bone grafting because of pain, donor-site morbidity, longer treatment time, higher cost, and fear of complications[8]. In a questionnaire-based survey, only 61% of patients accepted autologous bone grafts, and willingness dropped further for more invasive donor sites such as the hip[9]. Similar patient preference studies have confirmed that the origin of bone grafts, perceived morbidity, and financial burden influence treatment choices and acceptance of implant rehabilitation[10,11]. These findings suggest that treatment selection should not be based only on technical success, but also on the patient's practical and psychological acceptance of the proposed plan.

In daily clinical practice, however, implant systems are rarely compared using a standardized, transparent, and reproducible framework that integrates both clinical outcomes and patient-centered factors. Many clinicians compare systems informally, using factors such as the scientific literature, ease of use, implant cost, component availability, complication profile, patient satisfaction, and implant success. Although this pragmatic approach is common, it does not always make the reasoning behind treatment selection explicit or easy to communicate to colleagues and patients. A structured comparison tool may therefore be useful, especially when multiple criteria must be considered simultaneously and when both clinicians' and patients' perspectives must be included.

Decision-making frameworks have been used in other areas of medicine to organize complex choices, compare competing options, and make trade-offs more visible[12]. In implant dentistry, a similar framework could help clinicians compare technologies more systematically and improve discussions with patients who must weigh treatment burden against expected benefit[13]. However, a choice among the various two-stage systems utilized in the field of osseointegration is unwarranted, as all of these implant systems operate similarly and exhibit only marginal differences that do

not remain significant after multivariable adjustment. This assertion is supported by a comprehensive retrospective analysis conducted at the University of Michigan, which examined 550 implants and found that the effects of different implant systems were not independently significant following regression analysis[14].

The evolution of dental implantology has been significantly influenced by the widespread adoption of osseointegration, which has become the predominant paradigm in implant dentistry over the past several decades. This dominance has been supported by substantial industrial development, rigorous but "monotheistic", unidirectional academic research, and clinical standardization[15,16]. Nevertheless, alternative implant concepts, particularly those based on cortical anchorage, have been documented historically and continue to be refined as distinct therapeutic approaches[17,18]. These systems fundamentally differ in their design principles, biomechanical behavior, and clinical protocols, notably in their reduced reliance on bone augmentation and their immediate loading capabilities[17,18].

The coexistence of these divergent technological paradigms highlights the need for structured comparative frameworks that facilitate evaluation beyond conventional outcome measures. Specifically, variations in treatment workflows, complication profiles, and patient-related factors require systematic assessment to support informed clinical decision-making.

The 9-field matrix, commonly used in risk assessment and quality management, helps evaluate outcomes based on the interplay between the frequency of occurrence and the severity of consequences. This framework is especially effective in clinical decision-making, where it is essential to consider both the likelihood and impact of potential complications simultaneously.

The present article therefore introduces a multi-criteria framework for comparing the two available dental implant technologies (osseointegration vs. osseofixation) from both the provider and patient perspectives. It focuses on the use of a 9-field matrix as a practical decision tool and applies it to important clinical factors such as biological risk, mechanical stability, treatment complexity,

maintenance demands, and patient acceptance. By presenting the comparison in a structured format, the article aims to support clearer decision-making and to encourage a more balanced discussion of implant technologies in clinical practice[4].

Materials and Methods

This study was conceived as a conceptual methodological analysis aimed at establishing a structured approach for comparing dental implant technologies through the utilization of 9-field tables as an analytical instrument. This classification was based on qualitative synthesis and expert interpretation; no quantitative thresholds were applied. The objective of this methodology is to facilitate an objective and systematic investigation of the properties of various implant technologies by organizing pertinent clinical and practical parameters into a visual comparison model.

The comparison primarily emphasizes standard osseointegrated implants (SOI) as well as cortical and basal screw implants (CBI®), employed in osseofixation technology. Both clinical experience and available data have been taken into account in this comparative analysis.

The 9-field table constitutes the central methodological framework for this study. This model is inspired by methodologies employed in quality control and risk management, wherein outcomes or treatment options are assessed based on the interplay between the severity of damage or complications and the frequency of occurrence. Each parameter is situated within a 3×3 matrix, yielding nine possible fields that represent various combinations of severity and frequency. Technologies associated with high-frequency and high-severity complications are deemed less suitable, whereas those linked to low-frequency and low-severity outcomes are regarded as more favorable. This approach facilitates the visualization of trade-offs and promotes a structured comparison between treatment modalities.

A total of 16 fields of comparison were identified and analyzed, categorized into two primary groups: factors influencing treatment providers' decisions and factors influencing patients' decisions. The first group comprises six fields related to clinical and technical considerations, including biological complications,

mechanical complications, the need for additional surgical interventions such as bone augmentation, the management of complications, the applicability of the method across diverse clinical scenarios, and the availability of supporting literature. The second group consists of ten fields pertaining to patient-centered considerations, including treatment duration and healing phases, the need for bone augmentation, treatment costs, comfort and acceptance, maintenance needs, and the perceived risk of complications. These fields were selected based on their relevance to real-world clinical decision-making and patient preferences. The more patients research both treatment technologies, the more the two fields of decision-making will merge into one picture. In contemporary medical practice, it is increasingly evident that patients possess more information than many treatment providers do.

For each identified comparison field, both implant technologies were evaluated and positioned within the 9-field matrix according to their relative characteristics. The placement reflects the observed or reported tendencies of each technology in relation to the defined parameters. The results of these evaluations are presented in individual 9-field tables, allowing for direct visual comparison between the two technologies across multiple domains.

This methodology aims to provide a structured and visual comparison tool for implant technologies by integrating clinical observations and available data. The analysis focuses on identifying patterns and differences between technologies rather than conducting statistical comparisons.

Result

According to Table 1, for peri-implant conditions (G1), one system is located in the low-frequency and minimal-severity zone, whereas the other is positioned in the high-frequency and high-severity region. In the domain of mechanical complications (G2), one approach is associated with rare long-term structural events, while the alternative is distributed within moderate- to high-frequency categories.

Regarding surgical requirements (G3), one technology is consistently positioned in the low-risk domain due to the absence of augmentation procedures, whereas

the other is associated with higher frequency and severity of adjunctive interventions. A similar pattern is observed for corrective interventions (G4), where one system aligns with lower intervention burden and the other with moderate to high treatment complexity.

In relation to supporting evidence (G5), differences are observed in the nature and structure of available literature. For treatment planning flexibility (G6), one system is positioned in the low-severity domain, indicating fewer procedural constraints, while the other is associated with greater limitations.

Severity of Resulting Damage ↓ / Frequency of Occurrence →	Rare / Very Low	Medium	High / Frequent
Peri-Implantitis (G1)			
Severe damage (chronic pain, massive bone loss, suppuration)			SOI
Medium damage (pain, suppuration)			
Minimal or no damage (no clinical changes)	CBI®		
Fracture of Implants / Abutments (G2)			
High invasiveness of treatment, replacement of prosthetic work piece and healing			SOI (mini implants)
Early correctable implant replacement or simple renewal		SOI	
Very rare (<0.5%), implant fractures after many years	CBI®		
Bone Augmentation (G3)			
Severe damage to adjacent bone, pain, graft loss, pain			SOI
Medium damage, pain, partial graft loss		SOI	
No augmentation, no additional risk, no damages due to augmentation	CBI®		
Corrective Interventions (G4)			
Significant effort: bone augmentation, followed by implant replacement			SOI (bone augmentation)
Moderate effort: implant placement with unloaded healing periods		SOI	
Most problems solved immediately with immediate loading protocol	CBI®		

Severity of Resulting Damage ↓ / Frequency of Occurrence →	Rare / Very Low	Medium	High / Frequent
Nature of Supporting Evidence (G5)			
No studies available that respect ITT principle, applicability and validity			SOI
Small studies with limited number of implants and shorter follow-up			
Well controlled studies without any patient selection, with large number of implants (up to 17,000) over long periods	CBI®		
Tooth Removal / Planning Flexibility (G6)			
Teeth with remaining integration (five to ten years) cannot be extracted due to limitations in osseointegrated implant durability			SOI (restrictive treatment)
Partial extraction possible under constraints			
No limitation for extraction and bone adjustments	CBI®		

Table 1: Frequency–severity matrix comparing Corticobasal® (CBI®) and standard osseointegrated implants (SOI); red fields count as unacceptable, orange fields might count as acceptable under certain conditions, green fields hold the target situation with the least risks, damages and burdens.

According to Table 2, Corticobasal® implants (CBI®) are consistently positioned in the low-frequency and low-severity domains across patient-centered parameters, whereas standard osseointegrated implants (SOI) and related approaches are more frequently distributed in moderate to high burden categories.
CBI® are associated with the absence of unloaded healing phases, no need for bone augmentation, and lower initial treatment costs. In contrast, SOI are positioned in domains reflecting longer treatment duration, higher surgical burden, and increased costs. Similarly, CBI® align with lower maintenance requirements, more predictable esthetic outcomes, and reduced complexity of corrective interventions, whereas SOI are associated with higher follow-up burden, variability in esthetic outcomes, and more extensive retreatment requirements.
In the context of risk, approaches such as "All-on-4" and SOI are positioned in higher-frequency and higher-severity domains, while CBI® remain in lower-risk categories. Additionally, CBI® are associated with more structured training and system-related consistency compared to SOI.

Severity of Resulting Damage ↓ / Frequency of Occurrence →	Rare / Very Low	Medium	High / Frequent
Unloaded Healing Phases (P1)			
Months-long use of removable dentures, long periods without teeth, additional costs, due to integration of grafts			SOI
Unloaded healing phases present due to implant integration		SOI	
No unloaded healing phases	CBI®		
Bone Augmentation Burden (P2)			
Significant damage, long recovery, collateral damage at donor sites			SOI
Moderate damage, inflammation, suture dehiscence		SOI	
No augmentations at all, no damages due to augmentations	CBI®		
Initial Treatment Cost (P3)			
High cost (40,000 to 70,000 Euro)			SOI
Moderate cost (30,000 to 50,000 Euro)		SOI	
Lower cost (~20,000 Euro)	CBI®		
Risk in "All-on-4" vs. CBI® (P4 / P5)			
High risk of mechanical implant failure and mechanical prosthetic failure			All-on-4 / SOI
Moderate risk due to peri-implantitis			
Low risk of critical implant loss, very rare complications, close to zero mechanical failures	CBI®		

Severity of Resulting Damage ↓ / Frequency of Occurrence →	Rare / Very Low	Medium	High / Frequent
Cleaning and Maintenance Burden (P6)			
Intensive professional cleaning, multiple visits per year			SOI
Regular hygiene support required		SOI	
Basic hygiene sufficient, using interdental brushes and mild application of Waterpik®	CBI®		
Esthetic Outcome (P7 / P8)			
Unpredictable esthetic results after augmentations			SOI
Moderately predictable outcomes		SOI	
Predictable esthetic outcome if the technology of bone reduction is applied. Full control over the lip line	CBI®		
Corrective Interventions After Failure (P9 / P10)			
Re-implantation after bone augmentation, long waiting periods, lower success chances compared to the first intervention because the osteonal remodeling has been activated during the first interventions			SOI
Re-implantation with healing phases		SOI	
Immediate correction possible, no augmentation	CBI®		
Training and System Safety (P11)			
No standardized training, variable outcomes, no general rules for treatments			SOI
Partial guidance available			
Structured training, predictable outcomes, world-wide accepted and applied rules for both surgical and prosthetic treatments	CBI®		

Table 2: Composite 9-field matrix (patient-centered domains: CBI® vs. SOI). Red fields count as unacceptable, orange fields might count as acceptable under certain conditions, green fields stand for the optimum target situation with the least risks, damages and burdens. Products should be developed in a way that they will reach the green field under all angles of observation. The benchmark are the pre-existing registered products that are on the market. If large differences between the older product and the new product become obvious, the question of acceptability for the older products will or might be raised by the relevant authorities.

According to Table 3, Corticobasal® implants (CBI®) were associated with a reduction in chair-time and a decreased number of clinical appointments in comparison to standard osseointegrated implants (SOI). Notably, despite a higher quantity of implants utilized, CBI® exhibited lower material and laboratory costs, along with a diminished proportion of expenses related to the implants. Furthermore, the total cost billed to patients was lower for CBI®, and when adjusted for chair-time, the profit per hour was significantly higher for CBI® (€3,222) than for SOI (€1,977).

S. No.	Criterion	Standard Osseointegrated Implants (SOI)	Corticobasal® Implants (CBI®)
1	Chair-time used for treatment*	Average 9 hours (at least)	5 hours (all in one go)
2	Number of appointments necessary	Minimum 10	Minimum 4
3	Number of implants	Assumed 6 per jaw = 12 total	~ 21 for 2 jaws
4	Material costs (implants and accessories)	350 € × 6 × 2 jaws = 4,200 €	~1,890 € (average)
5	Costs billed to patients	26,000 €	~20,000 € (upper range)
6	Percentage of costs for implant components	16%	9.5%
7	Laboratory costs	4,000 € (~15%)	2,000 € (~10%)
8	Profit per chair-time hour	1,977 €	3,222 € (+63%)

Table 3: Comparison of treatment workflow and economic parameters of CBI® vs. SOI.

Discussion

This study presents a systematic multi-criteria framework for evaluating dental implant technologies through a frequency-severity matrix methodology. The results showed significant disparities between Corticobasal® implants (CBI®) and standard osseointegrated implants (SOI) in clinical, patient-centered, and economic aspects. These findings underscore the need to move beyond singular outcome comparisons to comprehensive decision-making frameworks that capture real-world complexities.

This investigation highlights the vital impact of biological complications, especially peri-implantitis, on the long-term success of implants.

The placement of standard osseointegrated implants (SOI) into high-frequency-severity regions for peri-implant circumstances corresponds with current literature that suggests susceptibility associated with surface properties and crestal bone contact[19]. In contrast, clinical observations and cohort studies indicate that Corticobasal® implants, utilizing polished surfaces and cortical anchorage, elicit a distinct biological response associated with a reduced incidence of peri-implant inflammatory conditions[20,21,22]. The reason is that in thinner implant diameters, the bacterial load in the sulcus is incomparably lower than in larger diameters of implants, and at the same time, the potential response of the body is closer to the bacterial attack from the sulcus[20,21,22].

In the current study, mechanical stability was also compared. Conventional two-part implant systems introduce additional interfaces, such as abutment connections, which are recognized points of mechanical vulnerability[23]. Reports of screw loosening, fracture, and material fatigue are well documented in the literature. The matrix-based findings align with these observations, positioning SOI in higher complication domains[24,25]. In contrast, single-piece Corticobasal® systems eliminate the implant abutment interface and distribute occlusal forces through cortical structures, which may contribute to improved mechanical resilience[26].

In implantology, bone augmentation is an important factor, and in conventional implant placement, a large volume of bone is required. This step increases treatment duration, morbidity, and cost.

However, on CBI®, patients prefer the minimally invasive approach, reduced treatment duration, surgical exposure and cost. It is also reported that reduced treatment duration and early rehabilitation of functions influence treatment acceptance. This phenomenon has been identified as a principal deterrent to the acceptance of implant therapy[27]. Immediate loading protocols, as implemented in CBI® systems, circumvent these phases, thereby aligning with patient expectations for expedited rehabilitation[28].

Previous studies have demonstrated that the cost of dental implant treatment frequently serves as a critical determinant in patient acceptance, occasionally surpassing clinical considerations[29]. Furthermore, financial barriers continue to represent a significant reason for the refusal of treatment[30]. A patient-centered observational study conducted in the Western region of Saudi Arabia included a total of 1,182 participants, of whom 834 completed the survey and met the inclusion criteria. The findings indicated that cost was the primary reason participants did not consider dental implants, while the enhancement of mastication emerged as the principal motivator for demand[31].

Moreover, in a recent systematic review conducted by Felgner et al., which synthesized 233 primary studies from 49 countries, a total of 101 distinct factors influencing dental treatment decisions were identified. Notably, out-of-pocket payments and direct costs to patients emerged as some of the most frequently reported determinants of treatment acceptance or refusal. This finding underscores the notion that financial considerations often take precedence over purely clinical factors in the decision-making process regarding dental treatment[32].

CBI® system shows that despite a higher number of implants (which produces higher safety for the treatment, without including the danger of peri-implantitis), total costs may still be severely reduced, just as the number of appointments, etc.[22]. This article has introduced a 9-field matrix. These criteria could be used to make decisions for the selection of implants. Conventional comparisons of implant placement were based on parameters such as survival rates, bone presence, etc. However, this matrix provides a more comprehensive basis for comparison and addresses treatment cost, duration, patient acceptance, and

technical feasibility.

This study has multiple limitations. This study is based on a conceptual framework that incorporates clinical observation and previous studies. Moreover, factors such as study design, clinical expertise, reporting standards, and follow-up duration across the literature may influence the outcome. The qualitative characteristics of the matrix-based classification system introduce a degree of subjectivity that may subsequently constrain the reproducibility of results across evaluators.

Randomized controlled trials (RCTs) comparing various implant technology paradigms may pose significant implementation challenges due to heterogeneity in clinical indications, variations in treatment protocols, and ethical considerations related to patient preferences and clinician expertise. These factors can restrict the feasibility of rigorous randomization and standardization across study groups. Therefore, well-designed prospective cohort studies and registry-based analyses may offer valuable complementary evidence, particularly when conducted in centers with recognized expertise in specific implant systems.

Conclusion

The proposed 9-field decision matrix offers a practical framework to support clinicians in selecting of the two presently available implant technologies in a more systematic and evidence-informed manner, while also facilitating clearer communication with patients about expected risks, benefits, and treatment burden. This study demonstrates that when patient-related and provider-related parameters are evaluated simultaneously, meaningful differences between implant technologies become apparent, underscoring the value of multi-dimensional risk and benefit assessment in the two available fields of modern implant dentistry.

Overall, CBI® emerged as the preferred implant technology. Corticobasal® implants were predominantly placed in lower-frequency and lower-severity categories, whereas standard osseointegrated implants were more often associated with moderate to high clinical burden, greater treatment complexity, and increased maintenance requirements. These findings suggest that implant selection should not rely solely on isolated clinical outcomes, but rather on

an integrated assessment of biological behavior, mechanical stability, treatment workflow, patient acceptance, and economic impact.

Unfortunately, comparative randomized controlled trials between SOI and CBI® implant systems remain even theoretically impossible, because, as the literature shows, in the long-term study as published in EECI[33], success rates and circumstances of treatments between both technologies (osseointegration vs. osseofixation) differ significantly. This raises doubts if fully informed patients would be willing to stay in the osseointegration group in case that they were randomly assigned into it. RCTs are feasible only between treatment options that show far fewer differences between them. Differences between an "osseointegration group" and an "osseofixation group" are dramatic however. Since the ITT principle dictates that patients (once assigned to a group) have to remain and to be evaluated in their group, the highly praised RCT makes for the comparison as described here no sense from a methodological point of view.

Future research with the intention to compare both technologies should focus on doing solid cohort studies in centers that are specialized in one of the technologies rather than on comparative studies from one single center where the proficiency for both technologies can hardly be expected.

After the invention of the term "osseointegration" around 1990, many alternative oral implant technologies and valuable treatment options had to leave the markets. As we know today, this did not mean that they were bad, useless or worse than the technology of osseointegration, it only meant and means that those technologies did not have the support of dental mainstream media and the "sciences". Nevertheless, the "chosen technology" of osseointegration has since then had the support of industry and the scientific field.

Against all promises of industry and the support of universities, the technology of osseointegration cannot fulfill the demands of the patients. Osseointegration copies natural ("root form") teeth and thereby copies all their disadvantages as well, with early onset of peri-implantitis being the heaviest and most widespread disadvantage.

This disadvantage by itself makes it clear that osseointegrated implants are a remedy that may act worse than the disease. The technology of osseointegration may at best be called a "symptomatic technology". Furthermore, the concept of the "healing time" demands multi-piece implant structures. This leads to a number of weak components and makes the concept prone to fractures and failures of the connection area in general.

Implants for cortical anchorage were described by Grafelmann and Pasqualini, they were used by L. Linkow and other early implantologists. The development of useful variants of cortical implants could only start after the profession recognized that these implants differ significantly in the usage from osseointegrated implants and that the design of every single type of the implants in every detail is important for the function of the whole concept. The necessity of bone augmentation was eliminated by providing a large variety of implant diameters and lengths. Only after the insight had gained ground that the use of thin and polished cortical screw implants is a separate and new oral implant technology, with separate (but logical) rules and completely different treatment options, were the ties to rules and habits in the field of osseointegration cut off. Today, the method of osseofixation stands on its own, it is a true alternative to the older concept of osseointegration.

For the first time in the history of oral implantology, two completely different technologies became available. It took another 1.5 decades until well-planned long-term studies were available. They showed that the new technology not only has the potential to outrun the technology of osseointegration technically, it is also much faster. In addition, it can be offered much cheaper to the patient, and at the same time, it seems to be more profitable for the treatment providers.

With the large differences between the two technologies given, a thorough comparison as done here makes sense.

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