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Immediate Implant Placement in Compromised Sockets

Immediate Dentoalveolar Restoration Technique

Inês Lourenço Ferreira

Dissertação conducente ao Grau de Mestre em

Medicina Dentária (Ciclo Integrado)

Gandra, 5 de junho de 2020

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Trabalho realizado sob a Orientação de Mestre Francisco Magalhães

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Eu, acima identificado, declaro ter atuado com absoluta integridade na elaboração deste trabalho, confirmo que em todo o trabalho conducente à sua elaboração não recorri a qualquer forma de falsificação de resultados ou à prática de plágio (ato pelo qual um indivíduo, mesmo por omissão, assume a autoria do trabalho intelectual pertencente a outrem, na sua totalidade ou em partes dele). Mais declaro que todas as frases que retirei de trabalhos anteriores pertencentes a outros autores foram referenciadas ou redigidas com novas palavras, tendo neste caso colocado a citação da fonte bibliográfica.

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Eu, "**Francisco Magalhães",** com a categoria profissional de **"Monitor Clínico"** do Instituto Universitário de Ciências da Saúde, tendo assumido o papel de Orientador da Dissertação intitulada *"Immediate Implant Placement in Compromised Sockets - Immediate Dentoalveolar Restoration Technique"*, do Aluno do Mestrado Integrado em Medicina Dentária, **"Inês Lourenço Ferreira"**, declaro que sou de parecer favorável para que a Dissertação possa ser depositada para análise do Arguente do Júri nomeado para o efeito para Admissão a provas públicas conducentes à obtenção do Grau de Mestre.

Gandra, __ de _____ de 2020

_____

O Orientador

AKNOWLEDGMENTS

I would like to start off by expressing my deepest appreciation to my family: to my parents for emotionally and financially supporting all my goals in life without ever doubting my capacity to achieve them and for always allowing me to be my own self and to my grandparents for raising me into the woman I am today with the greatest pride. A special thanks to my father for always being one phone-call away to help me solve all my problems, to my late grandfather for teaching me the best principles a human can possibly teach, to my grandmother for taking care of me like no one else, to my mother for always being there to calm me during my pre-exams crying-sessions and to my brother for being my best friend. I cannot stress enough the pillar they represent in my life.

I would also like to extend my sincere thanks to my boyfriend for supporting me unconditionally and for always helping me look on the bright side of things countless times, every day. I am also grateful to all my friends who have been a huge source of motivation and nurture my whole living-existence. Life is way easier with them by my side and so was my college journey.

A special thanks to my adviser, Prof. Francisco Magalhães. The success of this dissertation would not have been possible without his utter guidance and support throughout this whole process. His unconditional help was crucial since the day I submitted to this theme to the day I submitted my thesis. I would have not had it any other way.

I'd like to recognize, as well, the assistance of Dr. José Rosa, the creator of the IDR technique, since he never hesitated to answer to all my questions to improve the quality of my dissertation.

And last but not least, I want to thank myself for not giving up and persistently pushing through when things seemed impossible and life got tough.

RESUMO

A implantologia é o ramo de Medicina Dentária dedicado à reabilitação oral fixa, que restaura características estéticas e funcionais a partir da integração óssea de raízes artificiais com o intuito de substituir peças dentárias ausentes. O sucesso clínico dos implantes orais é influenciado e determinado por vários fatores-chave, tais como: sucesso da osseointegração, remodelação alveolar, volume da tábua óssea vestibular e contorno, forma e estabilidade dos tecidos moles circundantes. A colocação de implantes imediatos tem fornecido resultados de tratamento previsíveis, oferecendo vantagens em termos de conforto e minimização de procedimentos demorados de plastia tecidual. Contudo, a colocação endóssea de implantes em alvéolos comprometidos, que apresentam defeitos devido a trauma, patologia periodontal, falha endodôntica ou fratura radicular, enfrenta inúmeras limitações para preservar os tecidos de suporte periodontal pós-exodontia sendo que nenhuma técnica abordada na literatura médica ultrapassa completamente todos os obstáculos impostos. Assim, foi desenvolvida a técnica Restauração Dentoalveolar Imediata, um procedimento inovador, minimamente invasivo, sem realização de retalho e realizado em alvéolos danificados, que utiliza a tuberosidade maxilar como área dadora de enxerto com o objetivo de resolver problemas estéticos e otimizar resultados funcionais. Esta técnica baseia-se na premissa de tentativa de reconstrução total em apenas um passo cirúrgico, eliminando a necessidade de cirurgias adicionais e minimizando o custo, morbidade e riscos imprevisíveis estéticos através da aceleração do processo de reabilitação tecidual peri-implantar.

PALAVRAS-CHAVE:

"Restauração Dentoalveolar Imediata"; "Enxerto da tuberosidade"; "Provisionalização Imediata"; "Diretrizes"; "Alvéolo fresco".

ABSTRACT

Implantology is the field of Dentistry dedicated to fixed oral rehabilitation which restores aesthetics and functional characteristics via bone integration of artificial teeth roots in order to replace missing dental pieces. The clinical success of oral implants is influenced and determined by several key-factors such as: osseointegration success, dental socket remodulation, buccal bone plate volume and contour, shape and stability of the surrounding soft tissues. Immediate implant placement has provided predictable treatment outcomes while offering advantages in terms of comfort and minimization of gingival and osseous tissues' time-consuming plastic procedures. However, the placement of endosseous immediate implants into compromised sockets, which present bone wall defects due to trauma, periodontal disease, endodontic failure or root fracture, faces several limitations to preserve the post-extraction periodontal support tissues since none of the techniques approached in medical literature completely overcomes all the obstacles. Thus, was developed the Immediate Dentoalveolar Restoration technique, a novel, minimally invasive, flapless procedure performed in fresh damaged alveolus, which makes use of the maxillary tuberosity as the graft donor site in order to solve aesthetic problems and optimize functional results. This technique bases itself on the premise of a total reconstruction attempt in one surgical-step, eliminating the need of distinct surgeries and minimizing the cost, morbidity and aesthetic unpredictable risks by fastening the peri-implant tissue rehabilitation process.

KEY-WORDS

"Immediate Dentoalveolar Restoration"; "Tuberosity graft"; "Immediate provisionalization"; "Guidelines"; "Fresh socket".

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LIST OF ABBREVIATIONS

IIP – Immediate implant placement

IP – Immediate provisionalization

IDR – Immediate Dentoalveolar Restoration

PES – Pink Esthetic Score

APR – Alveolar ridge preservation

RP – Rapid Prototyping

CBCT – Cone Beam Computed Tomography

mm – Millimeters

3D – Three-dimensional

ALP – Alkaline Phosphatase

SOE – Slow Orthodontic Eruption

e.g – exempli gratia (for example)

1. INTRODUCTION

Esthetic dentistry has currently reached a sublimity degree that does not permit prosthetic works to not succeed in adequately providing an harmonious and natural appearance to oral structures.[1,2] Immediate implant placement (IIP) followed by immediate provisionalization (IP) after exodontia is a commonly practiced clinical procedure, especially in single esthetic maxillary restorations, that has provided predictable outcomes and high success rates identical to that of the implant placement in healed places[3,4], decreasing the demand for costly and time-consuming peri-implant tissue alterations after osseointegration.[5-7]

The possibility to maintain the anatomical architecture, restore esthetics immediately, have an excellent postoperative recovery, exclude the need for flaps, shorten the treatment duration, and the fact that certain forces have shown to play a crucial role in triggering biological reactions that accelerate the bone repair process, are the key-factors that preconize the immediate loading and provisionalization techniques, contributing to the maintenance of healthy peri-implant structures in intact sockets.[8-12] However, IIP in compromised alveolus, especially in the aesthetic zone, constitutes a meticulous and challenging procedure[13], considering greater involvement of the vestibular cortical bone is usually recognized[3,14] which may cause tissue recession and incomplete papillae, presenting an additional complexity for such cases.[15,16]

The existence of local infections is commonly contemplated an obstacle to IIP. Placing immediate implants in compromised sites due to periodontal pathology, endodontic failure, dental trauma or root fracture is frequently considered to be a high-risk procedure since inflammatory reactions, followed by the development of a bacterial biofilm in the socket or the bacterial diffusion in/from the fracture, frequently cause bone defects.[17,18] However, a systematic review regarding this subject matter revealed, despite the risk of immediately loaded implants failure placed into infected sites being superior when compared with implants placed into non-infected sites, excellent results are still registered.[3]

The first step in transitioning from a failing tooth to an implant-supported prosthesis is managing the post-extraction socket. *Elian et al.*[19] (2007) stated that compromised sockets require periodontal treatment and should be handled with a phased approach given that, posteriorly to alveolar healing, supplementary surgeries may be required before implant placement. Various treatment alternatives follow these premises, such as orthodontic slow eruption[20,21], Guided Bone Regeneration[13,18,22-28] and bone block grafting[18,25-27,29,30], associated or not with connective tissue grafts[13,31,32]. Notwithstanding, these protocols require flap-raising performances and demand a long-lasting treatment with delayed implant placement, conjugating two to three distinct clinical approaches.[25,27,33,34] Dr. José Carlos Rosa[26,35] proposed an innovative minimally invasive procedure – Immediate Dentoalveolar Restoration technique – with the purpose of reducing the rehabilitation time, which performs IIP and IP, making use of the maxillary tuberosity as the graft donor site to promote alveolar recovery in one surgical-stage and overcome several limitations presented by the remaining compromised-socket treatment techniques.[18,26,30]

Nonetheless, this integrative systematic review aims to study the efficacy of immediate implant placement in compromised sockets using the one-stage IDR protocol.

2. MATERIALS AND METHODS/METHOD

A comprehensive literature research was performed on PUBMED, EBSCOhost, Google Scholar and dental medicine indexed online journals (European Association for Osseointegration and Journal of Osseointegration), using the following key-words combinations: "Immediate Dentoalveolar Restoration" OR "Immediate Dentoalveolar Restoration" AND "Fresh socket" AND "Immediate provisionalization" AND "Tuberosity graft" OR "Immediate dentoalveolar restoration" AND "Tuberosity graft" OR "Immediate Dentoalveolar Restoration" AND "Immediate provisionalization" OR "Guidelines" AND "fresh socket". The inclusion criteria involved basic study design articles published only in the English or Portuguese languages, within a 10-year limit range (2009-2019), reporting the immediate implant placement in compromised sockets when using the IDR technique.

Exclusion criteria involved any paper written in another language besides the English and Portuguese idioms, studies performed in non-compromised sockets and papers that didn't fit in the primary medical-study category.

Initial potentially eligible hits, selected through title and abstract reading, were independently analyzed by two of the authors (IF, FM), whom held a preliminary evaluation discussion to select the relevant articles and establish which specifically met the purpose of the study. All records were compiled for each combination of key-terms and duplicates were removed using Mendeley citation manager. Selected hits were entirely read and evaluated in order to make a final decision according to the aim of this review. The following factors were retrieved for this integrative systematic review: author(s)'s name(s), publication year/title, purpose, study design, methodology, population, follow-up period, outcomes such as pink esthetic score, soft and hard tissue measurements and case results' clinical and imagiological findings, tuberosity's graft characteristics and final considerations, as reported on Table 1.

Online searches yielded a total of 158 initial hits considering all databases as followed: 46 on PubMed, 19 on EBSCOhost, 91 on Google Scholar and 2 on European Association for Osseointegration and Osseointegration journals, as showed on Diagram 1. After excluding 87 duplicated papers, 71 records were screened through title and abstract reading of which 48 were excluded since they did not meet the inclusion criteria. Consequently, 23 articles were entirely read for eligibility assessment; 5 studies were excluded for they did not furnish relevant data according to the purpose of this work. Thus, 18 records, all consisting of case reports, case series or prospective case series were included in this review.[2,4,13,18,21,25-30,33,35-40] Apart from these 18 studies, 7 additional articles, that did not meet the inclusion criteria, were obtained, through reference lists reading and independent manual research, to support the theoretical part of the results of this dissertation.

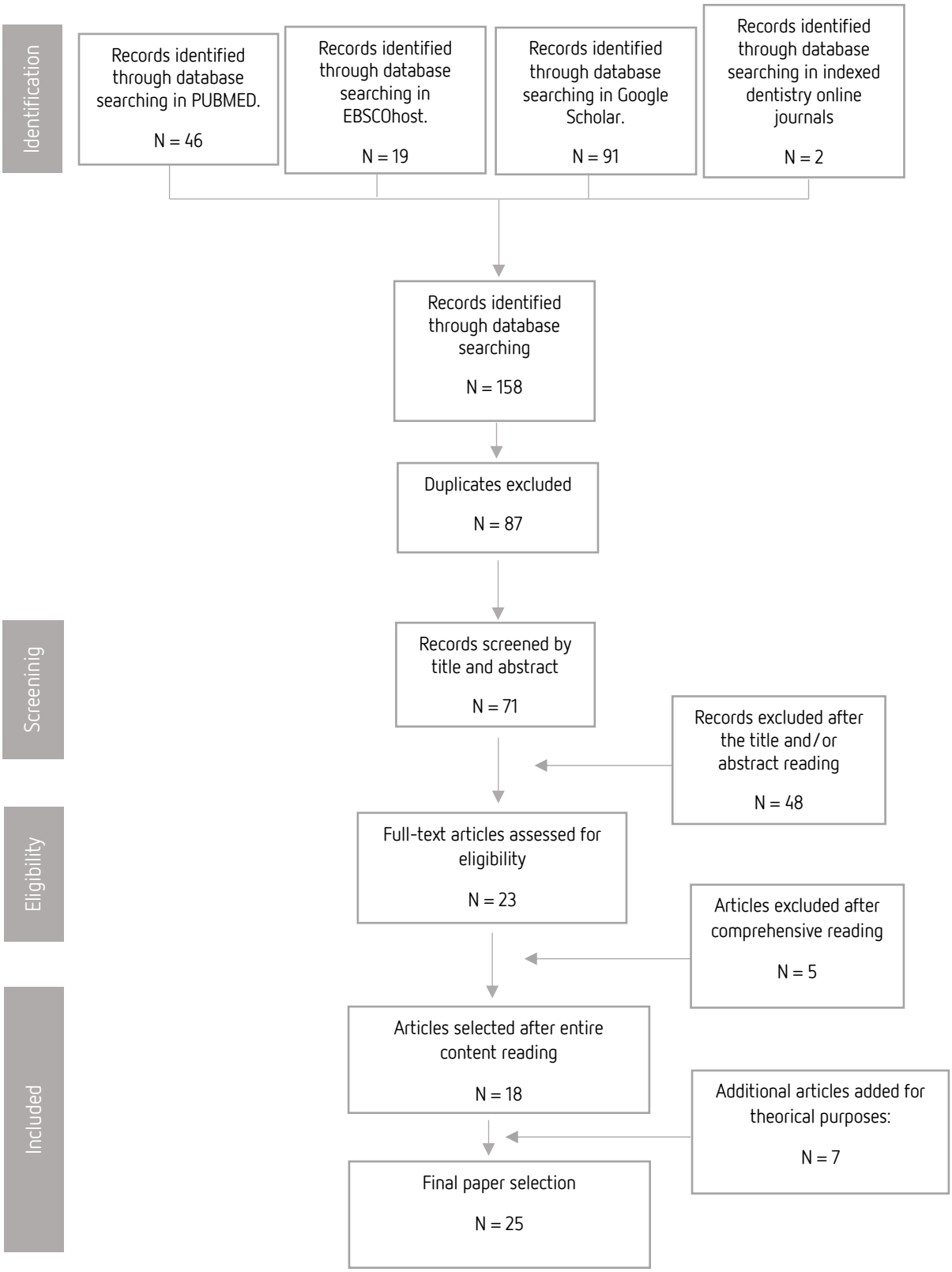


Diagram 1 – Flowchart presenting the steps performed to select eligible studies for this integrative systematic review.

3. RESULTS

As highlighted in Table 1, of the 18 studies selected: 1 (5,56%) mentioned the PES; 3 (16,67%) evaluated hard tissue remodulation; 2 (11,11%) assessed soft tissue dimensions; 18 (100%) performed a clinical assessment; 18 (100%) executed a medical imaging analysis regarding tissue outcomes; 17 (94,44%) described the characteristics of the maxillary tuberosity graft. All articles presented the same methodology, which consisted of immediate implant rehabilitation in compromised sockets under the IDR protocol, using multidisciplinary approaches or not, and 13 out of 18 papers (72,22%) presented a follow-up period superior to 2 years. The major retrieved data is drawn as follows:

Author's name/ Year	Title	Purpose	Study design	Methodology	Population (FDI)	Follow--up period	PES	Hard tissue measures (mm)	Soft tissue measures (mm)	Clinical Assessment	Medical Imaging Analysis	Tuberosity's Graft Characteristics	Final Considerations
Rosa JC et al.[39] (2009)	Immediate Dentoalveolar Restoration Post extraction With Platform Switching Implant Placement and Bone Grafting – A Clinical Case	To describe the IDR procedure in a compromised socket.	Clinical Case	• IDR Protocol	• Tooth 11	100 days	N/A	N/A	N/A	• Soft tissue volume increase due to platform switching and ideal emergence profile along with greater buccal bone crest width; • Tissue architecture reestablished;	• Thicker buccal bone wall presence due to palatine implant anchoring and bone grafting;	• Limited amount of bone; • Low density; • Difficult surgical access; • Excellent post-operatory recovery; • Easy to remove and adapt; • Malleability; • Trabecular characteristics; • High revascularization capacity; • Quick manipulation required;	• Buccal bone wall formation presenting adequate height and width due to correct bone graft positioning; • Gingival margin stabilization due to platform switching, emergence profile and adequate buccal wall;
Rosa JC et al.[33] (2009)	Reconstruction of Damaged Fresh Sockets by Connective-Bone Silver Graft from The Maxillary Tuberosity, To Enable Immediate Dentoalveolar Restoration (IDR) – A Clinical Case	To describe a procedure for IIP in a socket presenting severe buccal bone damage and gingival recession.	Case Report	• IDR Variation Protocol	• Tooth 11	24 months	N/A	N/A	N/A	• Gingival quality and thickness increase; • Gingival recession correction;	• Vestibular bone cortex recovery;	• Limited bone quantity; • Low bone quality; • Difficulty surgical access; • Greater graft repair speed; • Ease of harvesting and adapting; • Malleability; • Excellent postoperative recovery; • Osteoprogenitor cells;	• Enabled dentoalveolar restoration in a single procedure; • Although it requires long-term follow-up, the immediate results obtained were satisfactory and promising; • Minimized surgical trauma;

												• Trabecular nature; • High revascularization capacity; • Growth factors release; • Rapid transportation required; • Spongy bone; • Greater vascularization and cellularization; • Metabolically more active; • Impeded cell competition between the hard and soft tissues; • Effective bone and gingival healing;	
Rosa JC et al.[37] (2010)	Immediate Dentoalveolar Restoration - Immediate Loading of Implant in Damaged Fresh Extraction Socket with Gingival Architecture Involvement, Using Bone Silver Graft from Maxillary	To describe an immediate loading procedure in a damaged fresh socket.	Clinical Case	• IDR Protocol	• Tooth 11	5 months	N/A	N/A	• Incisal migration after 7 days: 1.5mm	• Greater soft tissue volume; • Maintenance of gingival margin leveling through biological periodontal distances reestablishment, after 65 days;	• Vestibular bone wall thickening;	• Excellent for small reconstructions; • Limited bone quantity; • Low bone density; • Difficulty surgical access; • Excellent recovery • Ease of harvesting and adapting; • Malleability; • May effectively serve as reliable and easy-to-harvest source of osteoprogenitor cells;	• Fresh damaged sockets reconstruction due to graft characteristics (cell competition inhibition) and early low-intensity stimulation; • Vestibular bone plate with adequate height and thickness formation due to palatine implant placement and

	Tuberosity: A Clinical Case											• Trabecular nature; • High revascularization capacity; • Growth factors release; • Quick manipulation required;	bone sliver correct positioning; • Gingival margin stabilization due to greater vestibular bone crest thickness, platform switching and emergence profile; • Primary stability was fundamental for the success;
Rosa JC et al.[18] (2013)	Recovering Function and Aesthetics of a Fractured Tooth Using the Immediate Dentialveolar Restoration Technique: Case Report With a 3 Year Follow-up	To describe a compromised socket restoration through IDR.	Case Report	• IDR Protocol	• Tooth 21	3 years	N/A	• Total remodeling: 1mm coronally from the platform	N/A	• Soft tissue stabilization maintained after 3 years;	• Interproximal bone stability; • Buccal bone wall restoration;	• Trabecular nature; • High revascularization capacity; • Growth factors release; • Quick transportation required;	• Fresh damaged sockets restoration with IP due to cortico-cancellous bone right manipulation and particulate bone condensation; • Avoids additional esthetically risky surgeries; • Viable and reproducible treatment alternative;
Rosa JC et al.[27] (2013)	Immediate Dentoalveolar Restoration of Compromised Sockets: A Novel Technique	To describe the one-stage technique (IDR) to restore peri-implant	Case Report	• IDR Protocol	• Tooth 21	36 months	N/A	N/A	N/A	• Peri-implant tissue health and stability; • Gingival margin and papillae levels and outlines similar to the contralateral tooth;	• Alveolar buccal plate defect reconstruction; • Height and thickness stabilization throughout the follow-up;	• Limited bone availability; • Excellent post-operative recovery; • Easily adapted; • Malleability; • Harvesting risks - sinus membrane	• May promote restoration of freshly damaged sockets; • Enables immediate provisionalization;

		bone defects, presenting the results of mid-term follow-up.										exposure and last molar roots damage; • Careful technical execution with adequate instruments; • Vascularization pattern; • Trabecular nature; • High revascularization capacity; • Reliable and easy-to-harvest osteoprogenitor cells source;	• Avoids additional risky interventions;
Rosa JC et al.[4] (2014)	Immediate Implant Placement, Reconstruction of Compromised Sockets, And Repair of Gingival Recession with a Triple Graft from The Maxillary Tuberosity: A Variation of The Immediate Dentoalveolar Restoration Technique	To present a treatment protocol consisting of IIP and bone a gingival reconstruction, in a single procedure, with a triple graft.	Clinical Report	• IDR Variation Protocol	• Tooth 11	2 years	N/A	N/A	N/A	• Bone and gingival architecture reestablishment; • Soft tissue enhancement over 2 years;	• Buccal bone wall stability;	• Difficult access; • Bone and soft tissue low availability to restore large defects or more than 1 tooth.; • Insufficient residual amount to make the implant's primary stability feasible in some occasions and treat gingival recession extending above the mucogingival line;	N/A
Rosa JC et al.[29] (2014)	Esthetic Outcomes and Tissue	To evaluate the	Prospe-ctive	• IDR Protocol	• 18 teeth: Maxillary premolars,	58 months	N/A	N/A	Mesial Papilla height:	• Stable soft tissue levels over a 58-month period;	• Buccal bone wall restoration	• Enhanced graft repair;	• Valuable and predictable option

	Stability of Implant Placement in Compromised Sockets Following Immediate Dentoalveolar Restoration: Results of A Prospective Case Series At 58 Months Follow-up	esthetic treatment stability after using the IDR concept.	Case Series		canines, and lateral or central incisors				• baseline : 4.34 ± 1.31 • follow-up: 4.54 ± 1.41 Distal Papilla height: • baseline : 3.60 ± 0.76 • follow-up: 3.90 ± 0.95 • Buccal mucosal recession: 0,06		after the follow-up;	• Osteoprogenitor cells; • Easy to harvest and adapt; • Malleability; • Restores the lost vestibular bone plate; • Impedes cell competition between hard and soft tissues; • Effective tissue healing; • Vascularization pattern; • Trabecular nature; • High revascularization capacity; • Growth factors release; • Short transportation--period required; • Limited quantity available; • Difficult surgical access;	for rehabilitation in the esthetic zone;
Rosa AC et al.[30] (2015)	Post-Traumatic Treatment of Maxillary Incisors by Immediate Dentoalveolar Restoration with Long-	To suggest the use of the IDR as an alternative to orthodontic forced eruption for	Case Report	• IDR Protocol	• Teeth 11 and 21	3 years	N/A	N/A	N/A	• Soft tissue volume stabilization;	• Buccal bone wall reestablishment;	• Osteoprogenitor cells; • Easy to harvest and adapt; • Malleability; • Restores lost bone plates; • Impedes cell competition between tissues;	• Predictable esthetic outcomes; • Soft and hard tissue stability;

	Term Follow-up	treating bone defect around a fractured tooth.										• Effective bone and gingival healing; • High revascularization capacity; • Growth factors release; • Fast transportation required; • Limited quantity available; • Difficult surgical access;	
Molon RS et al.[2] (2015)	Reconstruction of the Alveolar Buccal Bone Plate in Compromised Fresh Socket After Immediate Implant Placement Followed by Immediate Provisionalization	To reestablish the buccal bone wall after IIP with a connective-bone tuberosity graft.	Clinical Report	• IDR Variation Protocol	• Tooth 21	2 years	N/A	N/A	N/A	• Gingival architecture thickness and width increased; • No gingival recession;	• Horizontal and vertical bone formation with sufficient height and thickness; • Complete filling of the osseous defect without marginal bone loss;	• Advantageous compared to chin or retro-mandibular bone grafts; • Enhanced graft repair; • Osteoprogenitor cells; • Easy harvest and adaptation; • Malleability; • High revascularization capacity; • Growth factors release; • Trabecular nature; • Immediate function; • Minimal surgical time and trauma; • Less discomfort, swelling, and pain;	• Lost anatomical structures recovery with sufficient width and thickness; • Crest stability maintenance; • Harmonious gingival and bone architectures' efficient creation in a single procedure;

												• Limited bone quantity and surgical access;	
Rosa AC et al.[28] (2016)	Guidelines for Selecting the Implant Diameter During Immediate Implant Placement of a Fresh Extraction Socket: A Case Series	To propose a method for implant diameter selection to preserve the buccal bone wall.	Case Series	• IDR Protocol • Socket entrance measurement to determine the appropriate implant diameter.	20 teeth: maxillary lateral and central incisors and canines	35 months	N/A	Extraction socket entrance width: • Preoperative period: 7.07 ± 0.37 • Follow-up: 7.09 ± 0.35 Buccal plate width: • Crestal bone: 3.01 ± 0.18 • 2mm apically: 2.92 ± 0.38 • 4mm apically: 2.83 ± 0.42	N/A	• Tissue maturation observed 4 months later;	• Surgical complications not observed;	• Numerous vital periosteal and endosteal cells; • Revascularization pattern; • Trabecular structure; • High revascularization; • Bone growth factors release; • Limited bone available;	• Proposed method allowed favorable results regarding buccal plate preservation;
Junior W et al.[40] (2017)	Immediate Dentoalveolar Restoration Technique (IDR). Autograft Characterization and A Case Report	To present a case of implant rehabilitation through IDR as well as tomograph	Case Report	• IDR Protocol with cellular and molecular evaluations of maxillary tuberosity osteoblastic cells	• Tooth 14	3 years	N/A	N/A	N/A	• Gingival margin and papillae maintenance; • Soft tissue volume;	• Buccal and palatine walls complete remodulation; • Interproximal bone remodulation in the implant	• Easily shaped; • Biological barrier; • Stabilizes soft and particulate bone tissues; • Acts as a scaffold, filled with growth factors, ideal for	• When properly indicated and performed, exhibits high success rates;

		ic and cellular evidences to support this technique.									cervical, middle and apical thirds;	bone regeneration, with cellular growth; • Displays osteogenic features; • Displays osteoblast features as ALP activity, production of mineralized extracellular matrix and expression of a panel of bone markers genes;	
Cortasse B.[26] (2017)	Immediate Dentoalveolar Restoration – A New Perspective for Immediate Implant Placement in Compromised Sockets	To present the IDR protocol.	Case Report	• IDR Variation Protocol	• Tooth 11 • Tooth 21	1 year	High PES	N/A	N/A	• Bone and gingival architecture reestablishment (three-week postoperative); • Bone wall buccal convexity similar to the adjacent tooth; • Stable results maintenance 1 year later; • Healthy peri-implant soft tissue;	• Correct bone/graft integration;	• Limited quantity and access;	• Viable and predictable option for IIP in the aesthetic zone; • Avoids multiple surgical procedures;
Rosa JC et al.[36] (2017)	The Application of Rapid Prototyping to Improve Bone Reconstruction in Immediate Dentoalveolar Restoration: A Case Report	To describe the use of RP for tissue reconstruction of socket defects with IDR.	Case Report	• IDR Variation Protocol with RP	• Tooth 13	2 years	N/A	N/A	N/A	• Soft tissue volume; • Gingival margin and papillae stability;	• Buccal wall recovery, stable in terms of thickness and height; • Architecture maintenance after follow-up;	• Increased revascularization capacity; • Growth factors release; • Low density; • Thin cortical; • Easily shaped; • Biological barrier;	• High success rate when properly indicated; • RP enabled easier diagnosis of socket defects and faster and accurate graft adaptation;

												• Stabilizes soft and particulate bone tissues; • Porous volume; • Acts as a scaffold; • Source of osteoprogenitor cells and growth factors; • Ideal structure for bone regeneration;	
Rosa JC.[38] (2018)	Immediate Dentoalveolar Restoration in Compromised Sockets: Technique and Bone Biology	To describe the one-stage technique used to restore bone defects in compromised sockets and achieve soft tissue stability over time.	Case Report	• IDR Protocol	• Tooth 12	2 years	N/A	N/A	N/A	• Soft tissue volume; • Gingival margin and papillae stability;	• Buccal wall completely restored; • Relevant thickness;	• Harvest easily performed; • Malleability; • Adequate adaptation; • Biological membrane; • Promotes peri-implant tissue stabilization with effective healing; • Trabecular nature; • Increased revascularization capacity; • Low density; • Thin cortical; • Easily shaped; • Porous volume; • Acts as a scaffold structure for cellular and vascular growth; • Osteoprogenitor cells and growth factors source;	• Allowed implantation, flapless bone reconstruction and provisionalization in the same procedure, in an infected socket with severe bone defect; • Osseodensification strengthened the outcome; • IDR technique exhibits high success rates, when properly indicated and performed;
Rosa JC et al.[21] (2018)	Multidisciplinary Approach Using Slow	To present a multidiscip	Clinical Report	• IDR Protocol with SOE	• Teeth 11 and 21	3 years	N/A	N/A	N/A	• Soft tissue architecture maintenance;	• Excellent functional,	N/A	• These treatments, performed

	Orthodontic Extrusion and The Immediate Dentoalveolar Restoration Technique	linary treatment involving IIP and immediate reconstruction of alveolar bone defects.								• Gingival and papillary margins contours stability and esthetically pleasing;	biological, and esthetic result; • Vertical and horizontal bone stability;		together, can offer an excellent method for esthetic rehabilitation (particularly bone and soft tissues' vertical augmentation);
Franceschi RL et al.[13] (2018)	Application of Immediate Dentoalveolar Restoration in Alveolus Compromised with Loss of Immediate Implant in Esthetic Area	N/A	Case Report	• IDR Protocol • Reapplication of IDR Protocol after trauma • Connective tissue grafting	• Tooth 11	12 months	N/A	Buccal wall dimensions: Healthy tooth: • Cervical: 0,9 • Apical: 2,3 Tooth 11: • Cervical: 4,6 • Apical: 6,3	N/A	• Immediate postoperative with vestibular volume and gingival margin maintenance (1st attempt); • Gingival margin small recession compared to the other incisors;	• Vestibular bone wall significant increase: buccal bone of tooth 21 is less than 1mm; new vestibular wall of implant 11 exceeds 2mm;	• Provides different factors from traditional biomaterials; • Vascular pattern; • Medullary nature; • Transfer possibility of viable and high-capacity osteoprogenitor cells; • Effective healing • Minimal alteration to the involved tissues;	• Despite the implant osseointegration failure due to trauma, the success results when IDR is reapplied increases these technique's application possibilities;
Brum I et al.[35] (2019)	Immediate Dentoalveolar Restoration	To report a case of immediate dentoalveolar restora-tion.	Case Report	• IDR Protocol	Teeth 11 and 21	6 months	N/A	N/A	N/A	• Total soft tissue adaptation to the prosthesis;	• Peri-implant tissue complete adaptation; • No inflammation signs;	• Malleability; • Easy adaptation; • Greater graft repair speed; • Ease of harvesting; • Excellent postoperative recovery; • Low bone quality;	• Efficient procedure for recovering lost anatomical structure; • Hard and soft tissue stability throughout the follow-up;

												• Limited quantity; • Difficult surgical access;	
Rosa JC et al.[25] (2019)	Use of Immediate Dentoalveolar Restoration Technique Combined with Osseodensification in Periodontally Compromised Extraction Sites	To describe the combined use of IDR with the Osseodensification to improve primary stability in periodontally compromised sockets.	Case Reports	• IDR Protocol with Osseodensification	• Tooth 16 • Tooth 25	2 years	N/A	N/A	N/A	• Gingival margin and papillae volume stability;	• Buccal and palatal walls stability; • Adequate thickness;	• Low density; • Easily shaped; • Biologic barrier; • Stabilizes soft and particulate bone tissues; • Acts as a scaffold for cellular and vascular growth; • Filled with osteoprogenitor cells; • Ideal structure for regeneration;	• Adequate implant rehabilitation in fresh sockets with alveolar defects;

Table 1. Relevant data gathered from the selected studies.

4. DISCUSSION

1. Post-exodontia alveolus

a) Vestibular wall of the dental alveolus

The vestibular bone wall width of the superior anterior teeth is of 1mm[13,28] in approximately 90% of the patients, being composed essentially of cortical bone – it may present none or little medullary content. Considerably slim, this bone plate is constituted by three supply sources which are the periodontal ligament, the periosteum[2,25,36,38,40] and the bone marrow.[28]

b) Post-Exodontia Alveolus Biology and Alveolar Ridge Preservation (ARP) Techniques

From the moment the tooth is extracted, the blood supply deriving from the periodontal ligament becomes absent. If a flap is elevated, the second major irrigation source – the periosteum – is interrupted[2,25,36,38,40] and the bone tissue loses its supply until reanastomosis of the vessels unfolds. Thus, from a vascular supply point of view, an approach of the post-exodontia alveolus with no flap execution is an alternative to be considered as one more efficient to preserve the remaining bone, to allow rapid graft vascularization and to optimize the aesthetic outcome.[2,25,36,38,40] The gingival architecture is preserved considering the non-intrusive tissue manipulation, remaining, thereby, the periosteum integral which increases the foreseeability and successfulness of IIP.[2] Accordingly, it is pointless raising a mucogingival flap if gingival architecture preservation is a priority, since it has been evidenced that papilla-sparing incisions could diminish interproximal bone loss.[26,29] Like so, atraumatic tooth extraction recurring to minimally invasive surgical instruments must be held, as well, to preserve the remaining bone and papillae's integrity and optimize final results.[2,4,13,27,29]

Several studies suggest that IIP, when dealing with infected alveolus, is not recommended.[41] Root fractures and endodontically and/or periodontally compromised teeth frequently present some limitations regarding the immediate implant therapy execution[33] since it may cause relatively rapid bone resorption, leading to possible biological complications.[18] Acute infection, local edema and/or suppuration in the fresh alveolus heightens the failure risk since contraction and additional loss of periodontal tissues may occur, contraindicating the immediate loading of implant.[18,25,30,33,35,37,39] *Hegde R. et al.*[42] (2013), described a case of a tooth, presenting a periapical lesion, replaced with IIP, in the maxillary anterior zone – thorough alveolar debridement along with meticulous antibiotic administration allowed the achievement of successful results. Thus, regardless of the infection type, an effective strict therapy to control it ought to be implemented; careful curettage of the socket to remove granulation and periodontal connective tissues plus antibiotic prescription are mandatory in such circumstances.[2,4,3,18,21,25-30,33,35-40]

Remodeling of the alveolar margin after exodontia may lead to a 3.8mm (width) and 1.24mm (height) bone resorption in the initial half-year, continuing, annually, at a rate of 0,25-0,5%.[2] Even though alveolar preservation techniques seem to reduce the negative bone remodulation, none of the techniques approached in the literature is undoubtedly successful in completely avoiding tissue resorption, according to *Seyssens L et al.*[43] (2019). The one-year prospective study conducted by this author aimed to evaluate soft and hard tissues' modifications, 4 to 6 months following ARP of intact and nonintact alveolus, after grafting collagen-enriched deproteinized bovine bone mineral and saddle connective tissue, without flap elevation, in 14 patients. Bone resorption and gingival shrinkage occurred, being the maximum horizontal bone resorption and horizontal soft tissue contraction of 1.27mm and 0.87mm, respectively, at the most cervical aspect. Volume loss could not be avoided and was registered, mainly, at the vestibular aspect. Additional Guided Bone Regeneration was necessary in two nonintact buccal wall sites and additional soft tissue grafting was highly demanded. This study concluded that ARP did not prevent tissue changes even though IIP could be carried as planned.

c) Post-exodontia alveolus treated with immediate implant placement

Lazzara pioneered in introducing the immediate implant placement protocol, in 1989, to prevent significant bone volume reduction after long-healing periods.[41] The biological modifications that occur when implants are placed with an immediate approach play an important role in bone repair[18,33,35,37]; however, even though IIP after exodontia is a highly predictable procedure[18,29], implant placement, by itself, fails in preserving the alveolar dimensions[2,13,26,28]. Immediate implant placement in fresh sockets, with no other preservation measures, may result in bone ridge dimensional alterations with coronal-apical and buccal-palatal loss – a reduction in highness and a dislocation of the bone crest towards the palatal direction will occur, compromising the final outcome.[13,28] Therefore, IIP on its own does not eradicate alveolar bone remodulation, especially regarding the buccal bone wall.[13,28]

The loss of supporting structures heightens the non-esthetically-pleasing risk[26,29] since the buccal plate and the connective tissue width are clinically relevant to avoid midfacial recession and incomplete-papillae and achieve stable soft tissue contours in the esthetic zone.[4,18,29] Thus, treatment goals must comprise the reconstruction of absent anatomic structures[4,28,29] in type II (buccal plate dehiscence defect) and type III sockets (vestibular soft and hard tissues markedly reduced).[19]

The act of immediately placing the implant, in cases of intact alveolus, is notably well ingrained in the literature.[33,35] However, professionals of this field rate reconstruction of hard and soft tissues, of damaged sockets, along with IIP as an advanced complex procedure[2,4,13,25,30,35], since there may be greater involvement of the buccal cortical bone owing to its fragileness, thinness, reduced vascularization and sensitivity to occlusal forces[18,27,37,39] – furthermore, its resorption occurs faster than lingual/palatal plate resorption.[2] Treatment alternatives to rehabilitate damaged-morphology sockets are widely documented, such as orthodontic forced eruption[21,25,30], guided bone regeneration[13,18,25-30] and block-grafts[18,25-27,29,30]. However, multiple surgical procedures are customarily required (bone and/or gingival tissue grafting and implant insertion after a healing period), the esthetical results become less foreseeable when combined with aggravating factors (thin gingival phenotype[27,29]), a longer therapeutic time is required and

these are more expensive and present high-morbidity[27,40].[2,25-27,36,38,40] *Sarnachiaro GO et al.*[44] (2015) aimed to reconstruct type II sockets, in 10 patients, by performing guided bone regeneration with immediate implant placement under a flapless procedure. As result, the mean labial plate width gaining, according to CBCT scans, evolved from 0mm (pre-treatment) to 3mm after follow-up. In spite of the fact that satisfactory results were obtained, immediate provisionalization of the implant could not be executed, compromising the esthetical outcome.

Hence, the creation of the Immediate Dentoalveolar Restoration (IDR) technique – a flapless procedure, which aims at regenerating the post-extraction alveolus presenting one or more compromised walls.[2,4,13,18,21,25-30,33,35-40] Via an autogenous graft blockade sculptured to the wall defect, the particulate bone graft is condensed around the implant and IIP and IP are performed in one surgical-stage[13,18,21,25,27,29,30,36-40], resulting in a more rapid vascularization and incorporation of the implant, with null or minimal immune response, being, for the aforementioned reasons, designated the gold standard of regenerative procedures.[13,27]

2. Biological Principles of the IDR technique

a) Guidelines to select implants diameter and peri-implant gaps dimension

The anatomical teeth inclination contributes to the very thin vestibular bone plate shown at the dentoalveolar topography of the maxillary anterior sector, therefore, a more robust palatine bone wall is usually detected.[13] To obtain proper predictable mucosal results on the facial aspect, the bone wall must have sufficient height and thickness and the implant must be three-dimensionally installed in the correct buccolingual and coronoapical directions[29,37] (as portrayed by Buser), without over pressuring peri-implant tissues, which would contribute to suppress the blood supply and cause dehiscence defects[2].

The peri-implant gap is the space between the implant surface and the vestibular bone wall[13,28] created to accommodate the bone graft; in case of devoid of the hard tissue, it constitutes the space between the implant exterior and the buccal soft tissue internal portion[27,28] – If so, we are facing a damaged socket and regenerative techniques, as IDR, must be applied. Previous studies have shown, if the gap is wide-sized and its filling is not performed, there is a risk of continuous buccal bone plate resorption and, eventually, implant spirals exposure – the gap size will determine if filling it with particulate bone is required.[27,37] Supposing the width of the vestibular portion of the gap surpasses 2mm, a considerable amount of horizontal bone resorption may take place and tissue grafting, simultaneous to implant insertion, is necessary.[18] Additionally, some authors have affirmed that, in order to achieve peri-implant tissue optimal healing with IIP, at least 2mm of pre-surgical buccal bone must be present[13,28]. Thus, a 3mm gap should be intentionally created[2,13,21,25,26,28,29,36,38] to be filled with, preferentially, autogenous bone given that it delivers superior results regarding bone healing[37].

For the purpose of originating the 3mm peri-implant gap, the implant must be inserted by means of a palatal approach[13,18,21,29,33,35,38,39] to optimize esthetic results by assisting tissue accommodation.[2,4,25-27,36] The preparation of a bone bed following this criteria confers greater bone anchorage, better three-dimensional positioning to spread occlusal forces, greater bone quality and availability and formation of adequate conditions crucial to increase primary stability.[27,37]

However, the spatial positioning of the implant is directly determined by its dimensions and the diameter of the alveolar entrance.[37] In consideration of the foregoing, the implant's dimensions should be thoroughly selected to maintain the preconized peri-implant gap. *Rosa AC et al.*[28] (2016), verified that this step may be performed prior to the surgery, using images obtained through soft tissues CBCT slices. According to this methodology, if the vestibular-palatine extent of the alveolus is: inferior to 7mm, a narrow implant must be selected (around 3.5mm); equal to 7mm, a regular implant must be picked (around 4.3mm); superior to 7mm, a large diameter one must be elected (around 5.1mm). Its length must be 2-3mm more elongated than the socket itself to attain primary stability by introducing therein its apical third. This new protocol was based on a prospective clinical

case series, in which 20 patients were submitted to implant-rehabilitation in the anterior maxilla area. The socket opening buccal-palatal dimension was measured, the implant diameter was selected to intentionally create a 3mm gap and all gaps were, afterwards, filled with a maxillary tuberosity's bone graft. After, approximately, a 3-year follow-up, the mean buccal bone plate width measurements were 3,01 ± 0.18 mm, 2.92 ± 0.38 mm, and 2.83 ± 0.42 mm in the crestal bone at the implant platform level, 2mm and 4mm apically, respectively; the extraction socket measured 7.07 ± 0.37 mm and 7.09 ± 0.35 mm, during the preoperative and postoperative periods, respectively. Thereupon, significant changes were not verified. This new methodology implemented in the IDR technique has shown calculatable results in maintaining peri-implant tissue stability and vascularization.

b) Primary stability and Maxillary Tuberosity Graft

The initial stability of the implant is an essential factor that dictates its prognosis since it determines whether it can, indeed, be put into immediate use or not. The primary stability is defined by the value of the implant insertion torque – it is of the utmost importance that it is superior to 32-35Ncm[2,13,18,27-30,37,38] to obtain successful osseointegration results. However, ensuring a high primary stability to an immediately placed implant, especially when the buccal wall is partially or entirely incomplete, constitutes an intricate task; hence, the absolute need to insert the ideal implant in a palatal direction to prepare the 3mm space crucial to perform grafting.[25] The implant macrogeometry is not necessary to be specific, but it must contribute to the primary stability (e.g. conical-shaped implants).[2,13,33,37]

"*Graft revitalization and incorporation success depend on close contact between the graft and the host's vascular bed (Burchardt H 1983/1987, Abrektsson T 1980/1980, Gordh & Alberius 1999)*" (Rosa J, Rosa D, Zardo C, Rosa A, Canullo L.)[33].[25,27,37,38] In order to achieve this goal, the condensation of particulate bone within the implant surface, the alveolar walls and the corticocancellous graft is recommended to establishing an early close incorporation of the graft into the compromised socket[27,37] and avoid the micromovements of the implant[33], obtaining a secondary stability.[2,13,18,21,25-30,33,36-40]

Stability is also related to the characteristics of the grafted material. In spite of the progress in bone-substitute technology, according to *Tolstunov L*[45] (2009), autogenous bone is oftentimes preferable to allogenic, xenograft and synthetic bone substitutes as a result of its compatibility, biologic and nonimmunogenic properties. *Silva FM et al.*[46] (2006), performed a study to evaluate the morbidity and major adverse effects associated with the use of intraoral sources for graft harvesting before IIP: a degree level of lower lip and mental area sensory deficit was the greatest distress witnessed in 8,3% of the cases after ramus harvesting and 16% after mandibular symphysis graft collection, being that no complications were found involving the tuberosity graft. Moreover, previous papers have described the use of maxillary tuberosity grafts as ideal for correcting compromised socket since it provides different factors than the traditional biomaterials[13,37]. *Molon RS et al.*[2] corroborated the previous authors' statements , affirming, in one of his studies, that using this autogenous bone as a graft donor site offers various advantages compared to other sources, such as: greater speed of graft repair, easiness in harvesting and adapting to the receptor site due to its cortical bone thinness and malleability, excellent post-surgery recovery, trabecular nature (it presents around 70% of total porosity and 150 mm3 of porous volume[40]), higher metabolic activity rate and minimal trauma with less discomfort, swelling and pain[2].[18,25,27-30,33,35,37,39]

The endosteal and periosteal cells of this maxillary graft behave as osteoprogenitor units[13,25,30,36-39], consequently enhancing the initial osseointegration process.[2,28-30,33] A tuberosity cellular analysis performed in a study executed by *Junior W et al.*[40] (2017) showed these cells displayed osteoblast features, alkaline phosphatase activity, mineralized extracellular matrix production and expression of a bone marker genes panel, presenting this graft, accordingly, an ideal structure for bone regeneration since it acts as a natural scaffold[25,36,38] – attributable to its porous frame – filled with growth factors[18,25,28,30,33,36-39]; it contradicted previous studies whose authors claimed the maxillary tuberosities consisted mainly of marrow spaces and adipose tissue in a low vital bone profile. The tomographic and cellular evidences of this case report support the premise that using this autogenous bone, when accurately indicated, exhibits high levels of success[36,38,40].

To restore the lost vestibular bone plate, the corticocancellous tuberosity graft impedes cellular competition between bone and gingival tissues by virtue of acting as a biological barrier[36,38,40]; ergo, it stabilizes peri-implant structures by providing effective tissue healing.[29,30,33,38] Furthermore, the vascular arrangement is vital for the bone graft success – the medullary features of the tuberosity reveal this is, indeed, a viable donation source considering the possibility to transfer a bone portion with high osteogenic and revascularization aptitudes[2,18,27-29,36-39].[4,13,18,25,27,28,36-39] In three/four months, the tuberosity achieves its maximum mechanical resistance due to its total incorporation.[2,13,36]

As for the disadvantages, this autogenous bone can only be used in small reconstructions since it offers a limited available quantity[2,18,26-30,33,35,37,39] – this is considered a limitation of the technique if multiple rehabilitations are required, as insufficient amount of residual bone jeopardizes the implant primary stability.[4] It presents other discommodities, such as: low density[25,36,38,40], difficult surgical access[2,26,29,30,35] (particularly in patients exhibiting mouth opening constraint) and the necessity to be transported, manipulated and grafted rapidly to prevent the loss of fundamental properties such as cells viability[29,30].[18,33,37,39] Some potential entailed risks that may arise from its harvest are exposure of the sinus membrane and detriment to the last molar roots; for this reason, scrupulous technical implementation and the usage of adequate tools are required.[27]

Maxillary bone availability may be evaluated by visual examination, digital palpation, panoramic or periapical X-rays and computed tomography scans.[21,27,28,33,37-39] This technique should only be engaged conceding that sufficient bone volume is available.[18]

A paper published by *Rosa JC et al.*[37] (2010), presented a clinical case of a 52 year--old male whose upper right central incisor presented mobility, vestibular bone loss, probing depth of 7 mm, gingival recession of around 2 mm and thin gingival biotype with presence of a narrow keratinized mucosa band as clinical signs. The author utilized, as methodology, the IDR technique, using a corticocancellous tuberosity graft to repair the compromised socket. After 4 months of follow-up, despite the initial pre-surgical minor recession, a reestablishment of the biological width and, consequently, a greater stability of the gingival margin contour were clinically assessed; thickness increase of the vestibular wall was also detected as a result of the palatine implant anchoring under the proper insertion torque

along with the positioning of the tuberosity graft 1mm coronally to the implant platform. Another article, published by *Franceschi RL et al.*[13] (2018), after reapplying the aforesaid methodology upon implant failure due to trauma, presented very analogous results, corroborating the fact that this technique creates an osteoblasts nucleation-area. After analyzing the case's final tomography, the new formed vestibular wall measured 4.6mm and 6.3mm in the cervical and apical portions of the implant site, respectively, when compared to the homologous tooth (21), whose measurements at similar points recorded an archetypical bone board (0,9mm and 2,3mm, respectively).

However, if the compromised socket displays low bone density as a condition, correct adaptation of the graft and tight compaction of the particulate bone are fundamental to augment the alveolar denseness. In these cases, IDR may be performed along with the Osseodensification technique, a novel implant site preparation technology introduced by Huwais, based on the use of a specially designed bur which promotes a controlled plastic bone deformation due to its intimate rolling and sliding contact, along with the inner alveolus' surface.[25,38] *Rosa JC et al.*[25] (2019), associated the use of both the IDR and Osseodensification alveolar treatment methods to improve the primary stability of immediate implants inserted in two periodontally compromised extraction sockets presenting buccal and palatal bone loss. This article demonstrated that the Osseodensification preparation method allowed IIP effectively in a low remaining bone volume bed, with a primary stability of 50Ncm. It increased the peripheral mineral density around the osteotomy area and produced a compacted graft over the entire depth of the preparation site, providing a higher insertion torque due to the spring-back phenomenon. Histologic features have also validated that condensed bone grafts have the ability to physically interlink with the immediate implant surface[25,38] for it is placed in intimate contact, conferring the appropriate conditions to new bone formation and fast-paced osseointegration.

Conventional IDR does not incorporate soft tissue grafting procedures since it is based on the premise that a bone width of 3mm determines the soft tissues' layout.[13] However, mucogingival deformities can compromise the esthetical outcome. Therefore, exceptionally, a triple-layered graft[2,4,26,33,36] – connective tissue plus cortical and cancellous

bone – may be performed to treat large gingival recessions (greater than 1-2mm) and optimize the keratinized mucosa band, constituting a variation of this technique. Ultimately, it entirely depends on the patient's absolute demands, especially if vestibular bone wall loss is presented in combination with gingival recession[4,13,33] and/or thin periodontal biotype;[36] thuswise, a new periodontal biotype can be created. *Rosa JC* and colleagues[33] (2009), described the IDR variation treatment of an upper central incisor type III socket – showing a 4mm apical migration of the gingival epithelium combined with severe vestibular bone wall loss to a depth of 10mm – to recover the vestibular alveolar bone cortex. Clinical evaluation showed esthetical and functional expectable outcomes such as: bone thickness increase, quality of gingival anatomical contours, conversion to a thick periodontal biotype and bone-to-implant contact that is similar to delayed implants, immediately and after the 24-month-period follow-up. A published clinical report by the same author at a later date (2014)[4] employed the same treatment protocol to reconstruct a severe gingival recession and a damaged buccal bone wall, through a triple graft. Soft tissue enhancement and gingival anatomic contour along with bone wall reestablishment were identified in a 2-year follow-up CBCT scan and clinical photography, as predicted. An article published by *Cortasse B.*[26] (2017) corroborates the previous studies' results as it reported two clinical cases with a high PES, after 1 year of follow-up, with buccal bone wall convexity identical to the adjacent tooth and a CBCT scan confirmation of correct osseointegration after hybrid tuberosity graft insertion.

For the aforementioned reasons, it is suggested that the tuberosity structural and biological properties are determinant for the long-term success of the IDR technique.[25,36,38] The corticocancellous portion restores the socket anatomy while its juxtaposition in association with the particulate bone marrow compaction help to improve the alveolar density, increasing the long-term results predictability by facilitating the reanastomosis process and, subsequent, graft incorporation.

c) Immediate Provisionalization and Platform Switching

With the ongoing increase of esthetical demands by patients nowadays, surgical techniques are being enhanced and improved to reduce the healing period between implant placement and prosthetic restoration application.[2] "*According to Zhang, their analysis of patients who had received immediate, early or conventional loading showed that the patients who had undergone immediate loading had reduced marginal bone level changes in comparison with those who had not received immediate loading.*" (Brum I., Natal R., Pires J., Santos P., Carvalho M. Carvalho J.).[35] The immediate creation of conditions to maintain or achieve harmonious soft peri-implant tissue contours confers more anticipatable results than later trying to recover lost structures.[29,30] Moreover, success rates higher than 90% have been reported by some authors for IIP with immediate provisional fixed-prothesis loading.[35] As time goes by, supposing there is mechanical stabilization, early low-intensity incitement will increase the primary stability through augmentation of contact osteogenesis and local blood circulation, encouraging the one-stage protocol[13,18,27,33,37] – it fastens the bone graft repair process by reducing the time to load the implant with the definitive crown.[35,37]

The provisional restoration plays a critical biological and esthetical role in the development of the tissue ideal emergence profile. Since there are no pre-fabricated components presenting an anatomic configuration that adapts universally to all clinical situations, a personalized correct design of the temporary prosthesis is imperative.[29] The subcritical area must be pronouncedly concave around the cervical area at the vestibular and interproximal faces, allowing connective tissue' collagen fibers to accommodate without any compression – this guideline is crucial to assist gingival tissue physiological modulation around the implant since it creates a gap which promotes the attainment of thicker and more stable peri-implant gingival margins and papillae.[2,4,13,18,21,25-28,30,33,36-39] For the above-mentioned reasons, the IDR includes immediate provisionalization in the same surgical step as immediate implant placement. Thus, the confection of temporary prothesis must either allow gingival contour maintenance, if satisfying, or its formation or modification when not esthetically pleasing nor stable.

Complementarily, applying the platform switching concept – smaller diameter abutment than the implant platform[39] – is also decisive to boost the primary stability due

to the potentiality of covering the implant platform with the autogenous graft, increasing, thereby, the vestibular bone crest breadth. It concedes a space that helps to contain the blood clot and protect bone particles, and allows the preservation and stabilization of soft tissue levels, as well, since it reduces stress loads over the peri-implant structures.[2,37,39,40] A clinical case published by *Rosa JC et al.*[39] (2009), treated a superior central incisor presenting 12mm of probing depth, buccal bone defect, failed endodontic fistula presence, thin gingival biotype and narrow keratinized mucosa band. After 65 days of follow-up, clinical and tomographic assessments revealed that platform switching granted a crucial framework to attain a harmonious aspect to peri-implant soft tissues architecture - a greater buccal bone crest width associated with platform switching and optimal emergence profile, allowed the achievement of a greater soft tissue volume with gingival margin contour stability.

The final elaboration of the definitive crown takes place 3 to 6 months[2,4,13,18,21,25-30,33,35-40] posterior to the surgical phase and it must follow the same design presented by the subgingival portion of the provisory crown to perfectly adjust to the healed peri-implant tissues.

A prospective case series published, by *Rosa JC et al.*[29] (2014), aimed to evaluate the esthetic outcome and tissue stability when using the IDR technique in compromised sockets of non-recoverable teeth (central and lateral incisors, canines and pre-molars), in 18 patients presenting thin (11/18) or thick (7/18) gingival biotypes: IIP, IP, platform switching and tuberosity grafting were conducted as the technique protocol dictates. It was possible to perceive, when assessing gingival contour and papillae levels through clinical photographs that, after a mean follow-up of 58.56 ± 8.19 months, the mean mesial and distal papillary height values slightly increased, gradually, from 4.34 ± 1.31 mm to 4.54 ± 1.41mm and 3.60 ± 0.76 mm to 3.90 ± 0.95mm, respectively, indicating a volume augmentation peripheral to the definitive prothesis. Additionally, a minor insignificant recession of the mucosa on the facial aspect was registered (0,06 mm). Hence, anatomical delineation of the emergence profile associated with platform switching, used in the developmental phase of the provisional restoration to create a free space for the surrounding tissues, along with the wide advantages range of the maxillary tuberosity graft

are two factors that enable the achievement of stable, harmonious and predictable peri-implant soft tissue levels (regardless of the gingival phenotype) and restoration of the buccal bone wall/crest, during and after the monitoring period. A case report of the same author (2013)[18] following the same methodology, presented similar results. Three years of follow-up show stability of both soft and hard tissues, as well as restoration of the buccal bone wall which remains stable after remodeling 1mm total coronally from the implant collar, crediting the steps undertaken in the IDR technique.

3. Immediate Dentoalveolar Restoration Technique

a) Diagnosis Auxiliary Methods

Considering that the IDR is a blind procedure, CBCT diagnostic imaging is fundamental to confirm bone defects measurements and the reminiscing alveolus's dimensions so the implant anchoring can be correctly planned.[4,13,18,21,25-30,35,36,38,40] In like manner, it is also used to assess and register follow-up results[2,4,13,18,25-30,36,38-40], as well as periapical radiographies.[2,21,25,35,37-40]

Rapid Prototyping may also be used to improve bone reconstruction in Immediate Dentoalveolar Restoration since it reproduces a 3-dimensional skeleton of the interest area (tooth, bone defect and alveolus), from a digital file, generated by CBCT scans, which is later three-dimensionally printed. (Figure 1). It serves as a base model for the entire procedure, aiding the dimensional planning of the graft harvesting and shaping, to the ideal arrangement, plus its proper embedding, in a flapless procedure (Figure 2).[36,47] *Rosa JC et al.*[36] (2017), combined the IDR variation technique with RP: a 4-month follow-up CBCT showed total graft incorporation with significant thickness. A new prototype obtained, from the 2-year follow-up CBCT, showed buccal bone wall and gingival architecture stability in terms of volume maintenance.

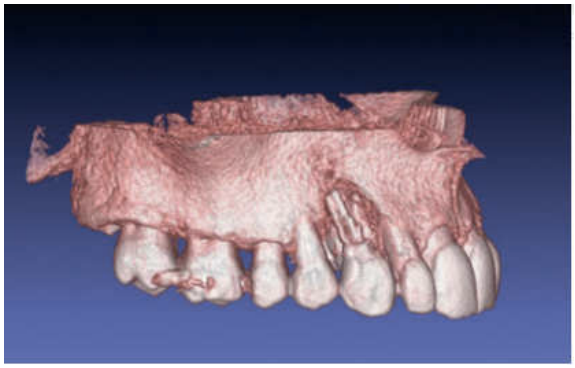


Figure 1 – 3D image showing buccal bone defect.

Figure 2 – Alveolar defect measured through the RP model.

b) Technique Protocol

After confirming the tooth condemnation to be extracted (Figures 3 and 4), the patient is informed about the treatment plan and requested to sign a written consent form.[2,27,35]

Figure 3 – Clinical assessment of the compromised left central incisor.

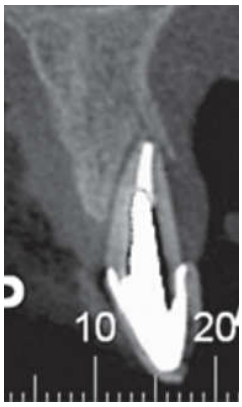


Figure 4 – CBCT showing buccal bone loss at the cervical third and good bone availability beyond the root apex.

Before surgery, antibiotics must be prescript to eliminate focal infection points. Patients are instructed to wash their oral cavity with a 0,12% chlorhexidine solution for 30 seconds immediately prior to surgery.[29,30]

When it comes to the exodontia-stage, the compromised tooth must be non-traumatically extracted under a flapless procedure[28-30,32,35,37-40] (Figure 5) – after anesthesia administration, an intrasulcular incision must be performed around the dental piece using a microsurgical blade, followed by luxation with pendular movements conducted in the mesial-distal direction. Afterwards, a thorough curettage of the receptor-bed must be effectuated.[2,4,13,18,21,25,26,28-30,33,36-38,40]

After exodontia, a periodontal probe is used to verify the alveolar anatomical shape by measuring its mesial-distal dimension and bone level height to determine its damage-degree (Figure 6).

The proper implant is, then, selected and inserted, following all the necessary steps of drilling, with its platform positioned 3mm apically to the gingival margin[2,13,18,21,25-28,33,35-40] under a minimum insertion torque of 32-35Ncm[13,18,27-30,37,38], strictly obeying the abovementioned guidelines.[2,4,13,18,21,25-30,33,35-40] (Figure 7) The adjacent teeth cementoenamel junction may also set as reference to estimate the drilling depth in case gingival recession is observed.[33,34,36,41]

Figure 5 – Minimally invasive extracted tooth showing a root fracture.

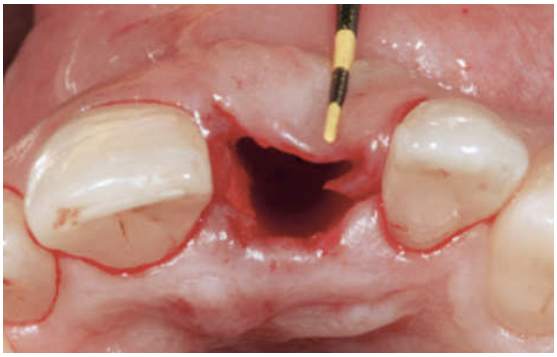


Figure 6 – Clinical assessment showing absence of the buccal bone wall after exodontia.

The provisional crown must be constructed before the grafting procedure is performed with the purpose of avoiding the risk of graft contamination while handling prosthetic materials – it can be manufactured previously to the surgery, on the study model cast, or from the tooth itself.[2,4,13,18,21,25-30,33,35-40] Centric and eccentric loading shall be eliminated, the ideal emergence profile must be established and its abutment must follow the platform switching concept.[17,18,27-31,33-41] The next step is to remeasure the socket defect (Figures 8 and 9) to simulate the affected area, so the harvesting process may be initiated.[2,27-29,39] (Figure 10)

After infiltrative anesthesia administration to the selected maxillary tuberosity, a posterior-anterior incision deepened along its entire length – starting at the center of the tuberosity crest, ending at the distal face of the last molar tooth – is performed to allow direct access to the donor area.[2,13,18,26,27,29,30,33,37,39] A straight chisel, 2mm wider than the width of the defect, is selected to the corticocancellous portion osteotomy, moving from a

perpendicular position to the bone surface on the incision line to a parallel position as it moves into a distal direction; an additional medullar portion is harvested as well.[2,18,26,27,29,30,37-39] If the available access area is not large enough, a third molar is present or the surgeon intends to harvest a triple graft, a releasing incision may be executed to extract the bone graft from the tuberosity lateral aspect.[2,4,13,27,29,30,33,36,37] (Figure 11)

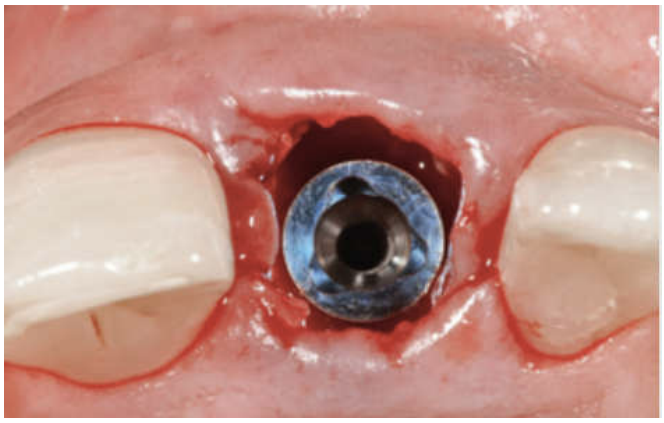
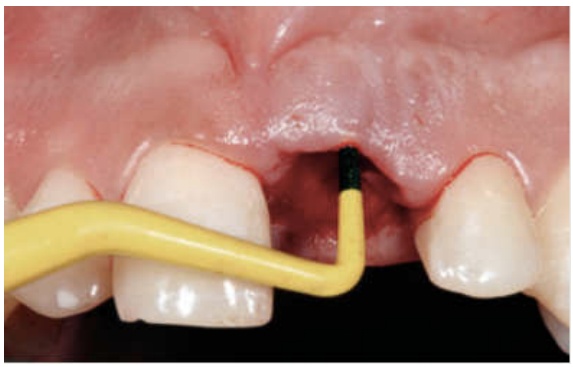
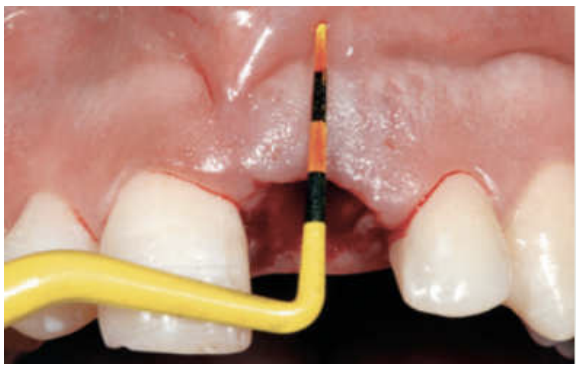


Figure 7 – Immediately placed implant with a palatal anchorage, 3mm apically of the gingival margin.





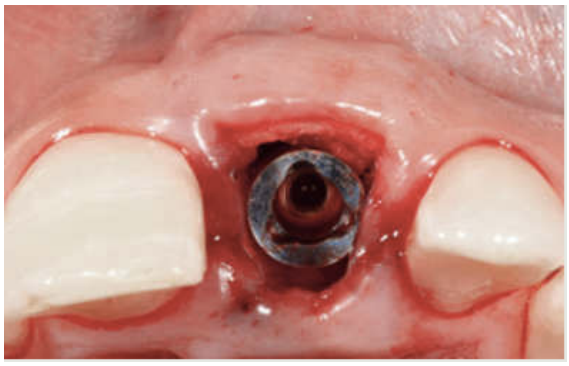
Figures 8 and 9 – Periodontal probe measuring the compromised socket's damage degree.

Figure 10 – Outlined direct copy of the damaged area to be reconstructed., using blood from the alveolus.

Figure 11 – Bone graft collected from the maxillary tuberosity lateral portion.

Posteriorly, the 3mm bone graft is quickly carved and resized, using a rongeur to contour the edges according to the receptor bed configuration[2,13,18,21,26-30,36-40] (Figure 12), and inserted 1mm above the implant platform, with the cortex or connective surface facing towards the vestibular aspect (Figures 13 and 14).[17,18,27,29-31,33,34,36,39,40] Subsequently, the particulate bone marrow (triturated beforehand with a rongeur) is delicately inserted and condensed in small increments, in an apical-coronal direction, interposed between the medullary portion of the graft and the implant surface.[2,13,18,21,25-30,33,36-40] (Figure 15) The condensation stage must be operationalized recurring to appropriate instruments in order to avoid graft dislocation, such as small bone compactors for the apical area and larger diameter compactors for the coronal defect region.[27]

Figure 12 – Graft positioned on the gingival surface to simulate its final position.



Figures 13 and 14 – Corticocancellous graft insertion with its cortical portion facing towards the vestibular aspect.

As earlier referred, a mucogingival flap may be raised, either previously to the exodontia process or before harvesting[16,34,36,41], if its coronal reposition is intended, to minimize tissue trauma. The triple graft connective portion may be sutured to mucogingival flap inner surface with the aim of achieving its stabilization; one simple stitch is further

comprised in each papilla to coronally stabilize the flap, providing first intention wound healing.[16,32,34,36,41]

The final step relies on the provisional crown reinstallation, after finished and polished.[2,18,37-40,21,26-30,33,36] (Figures 16 and 17) Sealing of the gingival margin is performed if no apical recession of the gingival epithelium is observed[17,18,27,29,32,35,40]; on the contrary, if minimal soft tissue recession is present, the gap is filled with blood from the tuberosity and the coagulum formation is awaited so the tissues can migrate in a coronal direction. Only when the restorative procedure is complete, is the maxillary tuberosity sutured with simple stitches.[27,29,30,33,35,37,39]

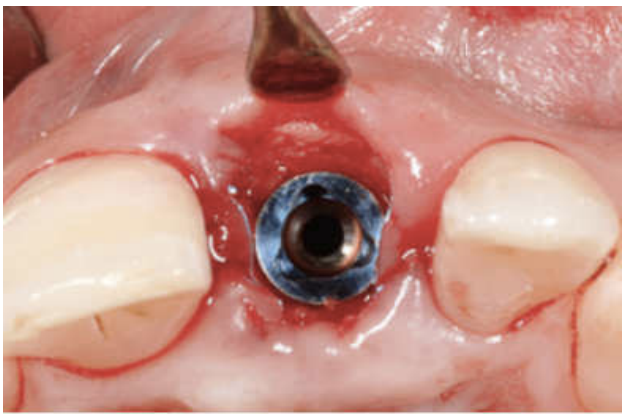
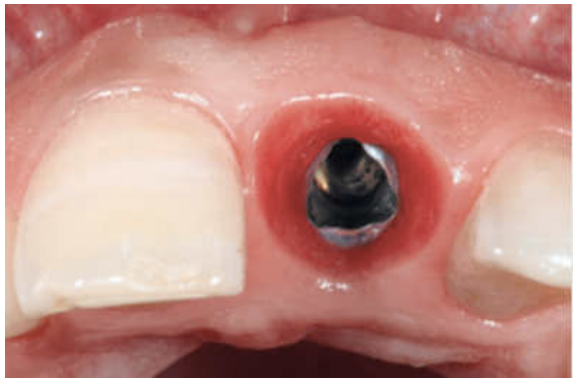


Figure 15 – Bone marrow interjacent between the implant surface and the medullary portion of the graft.

Figures 16 and 17 – Installment and sealing of the provisional crown, respectively.

After a 4-6 month period, once the architecture of the tissues has been reestablished (Figures 18 and 19), a careful impression to capture the healed tissues' emergence profile is obtained to confect the definitive crown.[2,4,35,36,38,40,21,25-30,33] (Figure 20) After occlusal and esthetical tests, the definitive restoration cementation is executed.[2,4,18,21,26,27,33,37]

Figures 18 and 19 – Correct soft tissue accommodation and periodontal biotype conversion, after 4 months of follow-up.

The postoperative instructions are to be executed to avoid complications in the follow-up outcomes. Some examples are: load avoidance on the treated area for three months; soft diet; 0,12% chlorhexidine gluconate topical appliance for 7 days, twice a day; smoking sobriety for, at least, 2 weeks.[13,27,33,35,37,39]

Figure 20 – Emergence profile reproduced on plaster model.

Clinical and radiographical monitoring is conducted depending on the difficulty of the clinical case and according to what the surgeon believes is appropriate. Clinical assessment of the displayed photographs, retrieved from a case report published by *Rosa JC et al.*[27] in 2013, showed hard and soft tissues stability since no significant alterations were detected regarding the gingival margin or papillae levels when comparing to the homologous tooth (Figures 21 and 22). A CBCT scan slice evidenced the alveolus's buccal wall defect reconstruction, showing height, thickness and stability of the bone throughout 36 months of follow-up Figure 23).

Figures 21 and 22 – Stabilization of the soft tissue volume and architecture, after a 36-month follow-up.

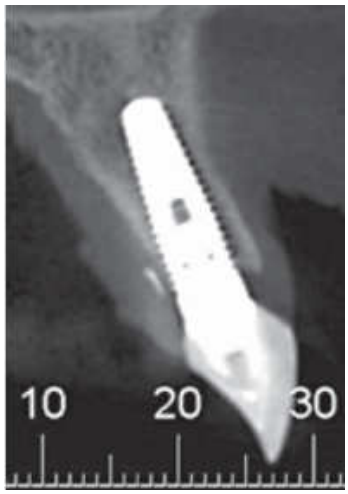


Figure 23 – Restoration of the buccal bone.

An article published by *Rosa AC et al.*[30] in 2015 executed the above detailed IDR protocol in both maxillary central incisors of an 18 year-old female; 3 years of follow-up showed total soft and hard tissue volume stabilization. *Brum I et al.*[35] (2019), registered identical conclusions as the aforementioned author: during the 6-months follow-up period, the IDR technique revealed to be an efficient procedure since it obtained as results, from an one-step surgical performance, total soft tissue adaptation in relation to the zirconia prothesis and complete integration of the peri-implant tissue without any signs of inflammation. The similarity in all case reports' results of the Immediate Dentoalveolar Restoration Technique validates the predictability and efficiency of this protocol to preserve and regenerate the natural biology.

5. CONCLUSION

Immediate Dentoalveolar Restoration is a viable, minimally invasive, predictable and reproducible technique which bases itself on the primary stability of both the implant and autogenous bone graft to achieve successful results. The IDR aims to reconstruct the post-exodontia alveolar bone, making use of the advantageous cytologic, topographic and vascularization characteristics of the maxillary tuberosity graft to perform immediate implant placement and immediate provisionalization in one surgical-step. The autogenous graft holds osseoinductive, osseoconductive and osteogenic potential; thence, these factors along with the biological principals of the protocol steps are the fundamental parameters that explain the attainment of a significative improvement of the volume and aesthetic aspects of peri-implant tissues, even in unfavorable periodontal biotypes. However, this is a sensitive, multidisciplinary and advanced procedure that should be solely undertaken by experienced clinicians capable of strictly following the protocol, since any loss of implant or graft stability would likely result in a complex failure that would require further reconstruction-stages. Nonetheless, clinical case reports published throughout the past 10 years addressing this subject have demonstrated the efficacy, predictability and stability regarding immediate implant placement in compromised sockets under the IDR technique, principally in the esthetic zone.

It should be noted that, despite the pleasing long-term outcomes presented in the literature, this technique is still in its embryonic-stage; further researches, comparing it with other techniques with follow-up results measured in detail would be of paramount importance to improve its scientific evidence.

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