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REVIEW ARTICLE

Maxillary immediate implant loading: A comprehensive review

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ABSTRACT

The incredible achievement of osseointegration and certainty of implant treatment modality in the mandible has provoked investigations, to look in the maxillary segment to check and understand if similar success rates can be achieved. This assessment of literature regarding this will give us knowledge about the various treatment modalities and investigations in an attempt understand the predictability and longevity of immediate implant loading in the maxilla carried out by various researchers. The basic nomenclature are considered and discussed, along with advantages and disadvantages of immediate loading, its relationship to osseointegration, its influence on primary stability and micro-motion. Excess weightage has been given to prosthodontically driven implant modality keeping the end-result in mind. Successful implementation of implant restorations can be done with the help of a few proposed guidelines.

Key words
Immediate implants, immediate provisionalization, immediate restorations, implant loading

INTRODUCTION

The art and science of modern dentistry has been revolutionised by implants, giving a new lease of life to the restorative aspects in day-to-day practise. For fully and partially edentulous arches it has transformed into a reliable and predictable treatment modality.[1-6] According to Branemark, before any restoration can be planned there should be a period of atleast four to six months.[7] Conventional loading[8] is a predictable and an accepted treatment modality that has been used as a benchmark to compare other implant loading protocols.[9] However, efforts have been made by various clinicians to discover possibilities to shorten the treatment time of implant supported restorations or by the placement into the extraction sockets immediately post-extraction.[2,3,10-13]

NOMENCLATURE

Cochran *et al.*[8] carried out an comprehensive review of the literature on implants and published their proposals giving the following terms:

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1. *Immediate restoration* (immediate provisionalisation) – restoration is delivered within 48hrs of implant placement but not in occlusion
2. *Immediate loading* – implant supported restoration is placed within 48 hours of implant placement and is in occlusion
3. *Early loading* - implant is restored with a fully functional restoration(in occlusion) at the second procedure between 48 hrs and three months from the time of implant placement
4. *Conventional loading* – the restoration is attached to the implant in the second procedure 3 to 6 months after the implant surgery
5. *Delayed loading* - an implant supported restoration is placed over the implant after a time period greater than six months.

ADVANTAGES OF IMMEDIATE LOADING

- Reduction in overall treatment time and alveolar ridge resorption[2,14]
- Offers an acceptable restoration esthetically[4,10,15-17]
- Increased patient acceptance[2,4,14,15,17]
- Quicker return of function[4,14,15,17]
- Removable prosthesis is avoided that may interfere with healing or simultaneous bone grafting and/or may require additional maintenance during the healing period[2,4,17]
- Potentially superior soft tissue profile when accompanying immediate dental implant placement[12,14,18,19]
- Reduced surgical trauma and ease of surgery.[14,20,21]

IMMEDIATE LOADING – SITE SPECIFICITY

Excellent longevity has been shown by immediate loading, which is a reliable treatment option of edentulous mandible. Chiapasco[3] described the overall survivability of immediate loaded overdentures as 98% and of fixed partial dentures as 95%. These studies included implants placed both interforaminally and more posteriorly in the mandible. This notable success in maxillary setting sought the application of similar treatment in the maxilla. Tarnow *et al.*[6] demonstrated that the possibility of immediate loading in the maxilla, was when they reported 100% survival of immediately loaded implants restored with a full-arch fixed prosthesis. However, a more limited degree of success in the maxilla vs the mandible because of the poorer bone density.[2,20] Lekholm and Zarb[22] described maxillary bone as more trabecular and softer in nature (also known as type 3 or type 4) while mandibular bone is more cancellous and denser (type 1 or type 2) which results in lower primary stability, greater micromotion, and a greater likelihood of fibrous healing and failure of implants to osseointegrate in the maxilla when implants are immediately loaded [Table 1].[17,23-31]

PRIMARY STABILITY

Primary stability has been classified as an important factor that determines implant success in immediately loaded implants.[32-34] Cameron[35] *et al.* first proposed in 1974 that the goal of primary stability is limitation of excessive micro-movement, which was later confirmed by Szmukler-Moncler.[36] The implant-bone relationship and prosthodontic design can influence micro-movement. This crucial in the maxilla, where the quality is typically less favourable. Fibrous healing instead of osseo-integration results due to excess of micro-movement.[4,23-25,37,38] Insertion torque -cited as an indicator of primary stability[2,39,40] and as a nonlinear, indirect indicator of micro-movement of an implant in bone.[24]

Table 1: Qualitative and quantitative factors that guide treatment planning of immediately loaded implants

Bone quality and quantity should be appropriate
The rate of bone formation in a given region of the jaw should be considered
If required, extractions should be atraumatic
Initial implant stability (torque at the time of placement) at the time of surgery is crucial
Implant positioning should be prosthodontically driven
All forms of parafunctional habits should be avoided
Cautions should be taken in patients with specific and recent (within two years) systemic conditions (radiotherapy), excessive chronic smokers or alcohol users, and those with uncontrolled systemic conditions (e.g.: poorly controlled diabetes)
Implants should not be placed into extraction sockets if they are currently infected
Balanced occlusion against natural teeth or prosthesis should be ensured
A minimum of 32 N-cm of torque should be used at the time of implant placement (although protocols suggest torque as low as 25 N-cm)
The implant system should be conducive to high primary stability/initial torque
Splinting of implants (and cross arch stabilization) should be performed when possible
Prosthodontic rehabilitation should be balanced and passively fitting, and, if possible a non-functional occlusal scheme should be implemented
Rough surface rather than smooth surfaced implants should be used

BONE QUALITY

The quality and quantity of bone are the two more factors that affect primary stability. Maxillary immediate implant placement can be quite challenging because of factors like lesser bone density, a thin cortical plate and proximity to the maxillary sinus.[2,20] Successful osseointegration of immediately loaded maxillary implants can be determined by bone preservation by atraumatic extraction.[41] Quality and quantity of bone at the surgical site which aids in treatment planning can be evaluated with the assistance of radiographic investigations (such as cone beam computer tomography (CT) scans).[38] Others recommended using Hounsfield units as a means of assessing the bone density of sites which implants will be placed.[42,43]

Micro-movement levels that are between 50 and 150 μm are known to cause no detriment to osseointergration[2,4,14,24] even though early reports indicated that osseointegration could succeed with micromovements upto 500μm.[44] Recent recommendations consistent with these limits, indicate that torque values at the time of placement should be greater than 32 N-cm.[38,45] But what is seen is that even though they permit primary stability these ranges of torque values are non-detrimental to soft maxillary bone. At the histological level, collagen fiber formation forms in a transverse manner with secondary osteon formation rather than parallel orientation with large marrow spaces. Resisting the mechanical stresses of the function following healing is favoured by this histoanatomic difference.[43,46] Other recommendations have stated that a minimum of 3-5mm of vertical bone-to-implant contact should be attained to provide adequate primary stability to facilitate favourable osseointegration which is extremely critical for immediate implantation in a fresh extraction socket.

The timing of implant placement can be affected by the quantity of bone volume that is available to receive implant. Within the first 3-12 months of tooth extraction up to 50% loss of bone width[13,47-49] and 1.3-4.0mm loss of bone weight may occur. The rate of bone resorption can notably be affected by factors like whether site is of a single tooth or of multiple teeth.[13,48-50] When bone levels are examined, to preserve crestal bone[10,12,20,37] it is seen that immediate placement of implants has been used and has been shown to produce similar or better results than delayed implant placement.

Two key observations associated with immediate implant placement in fresh extraction sockets followed by immediate loading (preferably non-functional) being[20,50-55]: (1) the esthetic outcome seems to be equal if not superior, to the conventional approach; and (2) similar survival rates with conventional loading can be achieved at single implant sites when rough surfaced implants, achieving high torque values, are placed by experienced clinicians.

IMMEDIATE IMPLANTATION

Bone necrosis can be caused due to drilling temperatures being greater than 47°C for longer than 1 minute. Hence, as the recipient site is already partially prepared[47] it is desirable to have immediate implant placement. Canullo *et al*,[15] reported that in cases of immediate placement (1.7 mm) than with delayed placement (3.0 mm) extension of bone remodelling was less extensive. Despite this limit in the healing zone, it has been shown that

Table 2: Guidelines recommended if immediate implant placement and/or loading is to be considered

Excellent primary stability/initial torque of placement
Rigid splinting preferred over lone-standing adjacent implants[57,58]
Adequate keratinized tissue[59-65]
Use of a surgical guide[66]
Use of a cone beam computed tomography scan technology
Prosthodontically driven implant placement
Absence of residual infection at the placement site by removal of all contaminated tissue[67-71]

Table 3: Lengths and diameters of immediately loaded maxillary implants

Authors, y	Patients, *n*	Implants, *n*	Implant Length, mm	Implant diameter, mm	Torque, N-cm	Implant survival, %	Evaluation period, mo
Horiuchi *et al.* 2000	5	44	≥10	–	≥40	96.5	–
Olsson *et al.* 2001	10	61	–	–	–	95.4	12
Jaffin *et al.*[75]	34	236	≥8	–	–	93	–
Nikellis *et al.* 2004	40	102	–	–	–	100	12.0-24.0
Galluci *et al.* 2004	8(Md+/Mx)†	68	–	–	–	97.4	8.0-20.0
Balshi *et al.* 2005	55	552 (submerged implants included)	–	–	–	99	–
Tealdo *et al.*[76]	21	111	≥10	4	≥40	92.8	12
Pieri *et al.*[77]	22	103	≥10	>3.3	≥30	97.1	12
Misch and degid 2003	2	18	–	–	–	100	–
Degid and Piatelli 2003	14	133	8.0-15.0	3.2-5.5	<35	98.5	2.0-60.0
Degid *et al.* 2006	8	69	≥10	≥3.4	>25	100	12
Bergkvist *et al.*[74]	28	168	–	–	–	98.2	–
Ostman *et al.*[11,78]	20	123	≥8	>3.3	–	99.2	12
Nordin *et al.*[20]	19	119	≥10	≥3.3,110 had ≥4.1	≥35	98.3	24
Palattella *et al.* 2008	17	18	≥10	4.8	35	100	24
Hassanet *et al.* 2008	20	20	14.0-16.0	3.25-4.0	–	100	12
Boranat Lopez *et al.* 2009	12 (7 Mx)†	36 (27 Mx)†	>13	4.2	–	97.2	12.0-18.0
Cannulo *et al.* 2009	22	22	13	3.8 or 5.5	32.0-45.0	100	25
Collaert and De Bruyn[17]	25	195	8.0-15.0	3.5-4.0	–	100	3
Machtei *et al.* 2008	20	33 Mx, 16 Md †	11.0-15.0	3.25-4.0	35-60	83	12
Degidi *et al.* 2006	44	388	–	–	–	98	60
Bergkvist *et al.*[74]	28	168	10 or 12	3.3-4.8	–	98.2	8 and 32
Degidi *et al.* 2008	20	153	–	–	–	100	12
Peiri *et al.* 2009	23 (9 Mx, 15 Md)†	144 (66 Mx, 78 Md)†	≥10	3.3 or 4.0	>30	98.6	12
Testori *et al.*[79]	19	116	>8	≥3.75	≥32	97.4	37.8
Degidi *et al.*[41,71]	40	48	–	3	≥25	100	48
Ibanez *et al.*[26]	41 (23 Md, 26 Mx)†	343 (217 Mx, 126 Md)†	–	3.75-5.0	–	99.42	12.0-74.0
Schwartz-Arad *et al.*,[10]	87	210	>13	≥3.75	–	97.6	
Ostman *et al.*,[11,78]	37 (20 Md, 20 Mx)†	–	–	–	>30	100	
Degidi *et al.*,[71]	780	780 (393 Mx, 387 Md)†	13.0-18.0	3.0-6.5	–	99.5	
Mijiritsky *et al.*,[19]	16	24	13.0-16.0	3.3-5.5	≥32	95.8	

† – Indicates average

Table 4: Survival rates of immediately loaded rough surfaced implants in the maxilla

Authors, y	Patients, *n*	Implants, *n*	Implant Length, mm	Implant diameter, mm	Torque, N-cm	Implant survival, %	Evaluation period, mo
Tealdo *et al.*,[76]	21	111	≥10	4	≥40	92.8	12
Pieri *et al.*,[77,81]	22	103	≥10	>3.3	≥30	97.1	12
Degidi *et al.*,[71]	8	69	≥10	≥3.4	>25	100	12
Nordin *et al.*,[20]	19	119	≥10	≥3.3 (110 had ≥ 4.1)	≥35	98.3	24
Palattella *et al.*,2008	17	18	≥10	4.8	35	100	24
Hassan *et al.*,[47]	20	20	14-16	3.25-4.0	–	100	12
Boronat-Lopez *et al.*,2009	12 (7 Mx)†	36 (27 Mx)†	>13	4.2	–	97.2	12-18
Canullo *et al.*,[15]	22	22	13	3.8 or 5.5	32-45	100	25
Collaert and De Bruyn,[17]	25	195	8.0-15.0	3.5-4.0	–	100	3
Machtei *et al.*,2008	20	33 Mx, 16 Md†	11.0-15.0	3.25-4.0	35-60	83	12
Degidi *et al.*,[9]	44	388	–	–	–	98	60
Bergkvist *et al.*,[74]	28	168	10.0-12.0	3.3-4.8	–	98.2	8 and 32
Degidi *et al.*,[71]	20	153	–	–	–	100	12
Pieri *et al.*,[77]	23 (9 Mx, 5 Md)†	144 (66 Mx,78 Md)†	≥10	3.3 or 4.0	>30	98.6	12
Degidi *et al.*,[41]	40	48	–	3.0	≥25	100	48
Schwartz-Arad *et al.*,[10]	87	210	>13	≥3.75	–	97.6	6-52
Ostman *et al.*,[78]	37 (20 Mx, 20 Md)†	–	–	–	>30	100	3-6
Degidi *et al.*,[41]	780	780 (393 Mx, 387 Md)†	13.0-18.0	3.0-6.5	–	99	1-107
Mijiritsky *et al.*,[19]	16	24	13.0-16.0	3.3-5.5	≥32	95.8	24-72

†– Indicates average

bone can fill osseous defects around implants if they are three-walled in nature[13] and <1.5-2.0 mm wide.[12,13,37] When used in conjunction with immediately placed implants autogenous bone grafts have been seen to be more osteogenic.[47] However, disadvantages may include risk of failure due to residual periosteal infection,[56] unpredictable site morphology,[12] a potentially limited amount of soft tissue [Table 2].[12]

Prosthodontically dictated implant dentistry

This term promotes a reduction in implant micromovement through appropriately positioned and loaded restorations. Lateral forces greater than 30 N.cm have been shown to produce micromotions greater than 100 μm as axial implant loading is a desirable treatment goal. Nonaxial loading can also contribute to loosening of abutment screws which is a major cause of prosthodontic failure.[20,38,72-75] Nordin *et al*,[20] described factors that could be detrimental to a healing implant, those being a high precision and passively fitting prosthesis reduced stresses and strains. Some researchers have implemented splinting and cross-arch stabilization on implants that are not loaded along their long axis. Tealdo *et al*,[76] placed distal implants in an angulated manner, in an effort to avoid maxillary sinus. This technique has shown bone loss around the distal implants that is similar to that seen with more conventionally placed implants. Other researchers have demonstrated 100% survivability using a similar concept called V-II-V, whereby six implants are placed into the maxilla at 30-45 degree angulations to the occlusal plane in the posterior maxilla to avoid the maxillary sinus [Table 3].[80]

CONCLUSION

Recent reports [Table 4] suggest that survival of implants has increased following careful surgical protocols and its optimum implementation along with optimum restorative protocols with respect to designing and maintenance, periodic check-up and recall in addition to maintenance of a good oral hygiene. It is possible to simulate the long term success rates of mandible even in the maxilla following the necessary guidelines.

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