Review Article

Current Status of Implant Placement in dentistry: A Review Article

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ABSTRACT

The appeal and demand for implants had grown acutely since the past decades. Most patients nowadays choose implants compared to other prosthetic options. Further research and development lead to the digitalization of implant dentistry. Today, implant placement isn't limited to fixed principles. Robot implants have already been a success story. CAD-CAM and Fully computer-assisted implant placement are giving better control and precision over hand-guided implants.

This article discusses the scope of implant dentistry at present time. This article is an original article that distinctly discusses all the current possibilities and alternatives which a dentist/ periodontist can have while planning implant treatment.

Key words: Implant, piezosurgery, pterygoid, sinus, zygomatic

In the last two decades, Implants dentistry had made startling advancements. Hard and soft tissue augmentation, different positioning and angulation of implants, along with radiographic advancements set forth thequantum leap.The present-day philosophy of implant placement metamorphosed the concepts and practices of dentistry.

The ideas and concepts of periodontal therapy have changed forever, with the shift in conviction from "maintaining all teeth" to "extraction of teeth with poor/ questionable prognosis" and replacing them with dental implants for superior aesthetics and functional benefits, and long-term convenience.

What is to be considered and remembered is that: a temperature rise exceeding 47.1°C only for a minute, while drilling the bone can cause necrosis of the bone.[1]

Currently, zygomatic implants, pterygoid implants, Computer-guided implant placement, and robotic implant placement are subtly revolutionizing our prospects and approaches for implant placement.

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This brief review features all the current possibilities for implant placement.

Piezoelectric implant placement

In the year 2000, Tomaso Varcelotti reported the first human clinical study about piezoelectric bone surgery. Piezoelectric surgery gives the advantage of superior hemostasis, firmer control, and greater clarity in the operating field. Further, it also sterilizes the local operating area by imploding the bacterial wall.[2]

Principle

The creation of electrical tension on some crystal and ceramic materials such as quarts to which a mechanical pressure is eventually applied. (Figure 1)

Direct piezo effect

The principal is simple: Mechanical stress applied to piezoelectric material leads to the generation of electricity

Indirect piezo effect

The mechanical force generated leads to physical deformation (Restrained). The piezoelectric material thenGenerates electricity.

Application of Piezosurgery in Implantology

- Implant socket preservation.
- Alveolar ridge splitting & expansion.
- Maxillary sinus lift.
- Recontouring of alveolar crest.
- Nerve repositions.

The piezoelectric drill kit consists of:

- six insert tips which are available for implant site preparation of various dimensions
- two pilot cylindrical tips
- four conical ones, corresponding to the various implant diameter.

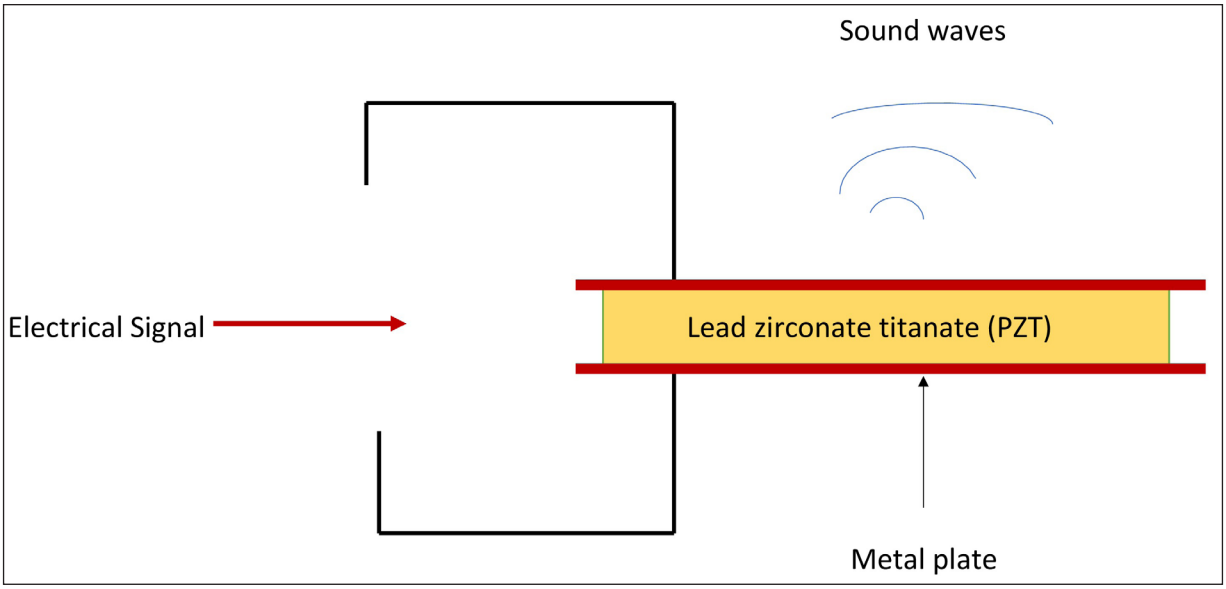

Figure 1: Principle of piezoelectric surgery

Piezosurgery shows a selective enlargement of only one socket wall. Vercelotti called it **"differential ultrasonic socket preparation"**.In the spotlight, a maximum load of 400g is to be used during implant site preparation.[3]

Literature Review: Studies have reported up to 97.74% implant survival rate with piezosurgery. The survival chances being more for mandible with 98.75% than for maxilla 96.99%.[4]

In sinus lift procedures, the piezoelectric bony window osteotomy can easily cut mineralized tissue without injuring the soft tissue. Piezosurgery separates the Schneiderian membrane without causing perforations resulting in a 95% success rate. The average time needed for piezo bony window osteotomy and membrane elevation was 3 mins and 5mins respectively.[5]

A reduced rate of incidence (from 30% to 7 %) was reported in a study of 100 cases using piezosurgery. In this study, all the perforations occurred during the hand instrumentation phase and not with the piezoelectric inserts.[6]

Piezosurgery is safer than conventional methods, and hence the marginal incidence of perforation!!

Piezoelectric devices use low-frequency ultrasonic micro-vibrations with specific amplitude to precisely cut bony structures without damaging the soft tissue.

The research reported that ultrasonic devices and bone scrapers had a lower occurrence rate (10.9 and 6.0%) of membrane perforation compared with that of rotating instruments (20.1%). The paper reported that thinning of the lateral wall of the sinus by using ultrasonic instruments or bone scrapers seemed to reduce the incidence of accidental sinus membrane perforations.[7]

The piezoelectric devices operate in a frequency range of 25-29KHz. Its high frequency and power help it to precisely penetrate highly mineralized bone. The insert tips have a linear micro-vibration pattern (60 to 210 μm) for osteotomy and osteoplasty making them suitable for preservation of the Schneiderian membrane.

The low frequency of the ultrasonics and the sharp instrumentation cuts through mineralized tissue easier than soft tissue. Moreover, the cutting process is safer near the soft tissue, with the diamond-coated instruments.[5]

A research paper by Torrella et al. described a lesser risk of sinus membrane perforation for the lateral approach with ultrasonics. The article further adds improved visibility and hygiene in the operating area and the controlled osseous incision.[8]A lower membrane perforation rate, improved intraoperative visibility, diminished intraoperative bleeding, and a lower rate of surgical trauma during the antrostomy and initial membrane elevation with piezoelectric inserts was reported by another research.[6]

Computer-Guided Implant Placement

CGI Putilizessurgical templates developed with CBCT and software programs that assist in the selection and placement of implants. It has better accuracy and precision when compared with Freehand drilling, where the clinician determines the angulation and depth of osteotomy preparation.

Advantage:

- Hardly any possibility of damaging adjacent vital structures.
- A more controlled work environment with prefabrication of the surgical template.

- Enables flapless surgery.

Fully Guided Implant Placement: In FGIP, surgical templates with their drill sleeves (bushings) control the implant osteotomy site's position, angulation, depth, and diameter.

It is indicated for edentulous patients.

2-piece surgical template provides more flexibility during the implant placement, soft-tissue manipulations,and regeneration procedures. It is used to make sure that the implants are placed perfectly parallel to each other.FGIPaids to perform the desired alveoloplasty before implant placement.

Disadvantages:

Lack of flexibility during surgery: Bone grafting is challenging with FGIP and Coronal – Apical positioning of Implants is difficult to visualize & control.

Lack of M-D and interocclusal space makes it more difficult to use in partially edentulous patients.

Semi-Guided Implant Placement

It uses similar treatment planning software programs as FGIP, but the drill sleeves (bushings) incorporated within the surgical templates are designed to accommodate the 2-3 mm twist drills and as a result, *control only the position, and angulation of the initial osteotomy*. Indicated in partially edentulous patients, the posterior quadrantswith limited interocclusal space.

In the Esthetic Zone, the Apical – coronal positioning and angulations are critical which permits bone and soft tissue grafting.

Literature Review: In a study comparing FGIP and HGIP, the FGIP showed higher accuracy thanHGIP.When compared, the results showed a statistically significant difference, although the accuracy of both was comparable.[9]

A research article compared FGIP with HGIP for several parameters. The FGIP was found to be more accurate compared with the latter. The study winds up that for both types of surgery, a safety margin of at least 2mm should be preserved during implant planning to prevent damage to nearby anatomical structures.[10]

Implants in Orthodontic Patients

Implants in orthodontic patients are used for two main purposes: (1) As an adjunct/ tool for growth studies, (2) As support for orthodontic teeth movement. In orthodontic teeth movement, the implant helps in retraction, protraction, distalization, and space closure of teeth.

Available as mini-implants (average length 11-21mm, diameter 3.5-5.5) and micro-implants (5-10 mm length and 1.2mm diameter)

A length of 6-8 mm is adequate for use in the maxilla, compared to 4-5 mm for mandible regarding the cost, size, the procedure of insertion, and bulkiness.

On Implants

In 1995, Block and Hoffman introduced a flat disc fixture of 8mm *10 mm dimensions, for space closure and molar distalization.

Ortho Implants

Celenza and Hochman introduced these endosseous implants, which are alike On implants. It is indicated for space closure and molar distalization. The Palatal bone support for the ortho implant is enough; it doesn't cause damage to the nasal floor (Heinrich et al 1999).[11]

Zygomatic ligature

0.9 mm stainless wire with NiTi coil spring is placed between the hole of first molars and mini plates. The mean time of intrusion of the upper anterior is approx. 5.5 months. Indicated for Canine distalization, IMF(Intermaxillary fixation), and molar distalization.

Complications of Orthodontic Implants

- Trauma to the supporting structures and teeth roots due to change in insertion angle.
- Mini screw slippage
- Nerve involvement
- Air subcutaneous emphysemas
- Nasal and maxillary sinus perforation
- Inflammation, infection, and periimplantitis
- Partial osseointegration.

Promises of Implant dentistry: The current options for dental implant placement are:

Tilted implants

- All in 4 concept
- Zygomatic implants
- Pterygoid implants
- Vomer nasal crest implants
- **Nanorobotics in implants**

Tilted implants

Introduced in the 1990s, Here the posterior implants are tilted at 30° angulation and placed parallel to the anterior wall of the max sinus. They give several advantages over conventional implants such as Improved stability, longer implants in the distal position, eliminating the need for sinus lift procedures.

The all-in 4 concepts, zygomatic and pterygoid implants are all distinct types of tilted implants.

The tilted implants have been shown more favorable biomechanically than the shorter implants with axial inclination using finite implant analysis.[12,13] Approx. >97% success rate has been reported with tilted implants in diverse researches.[12-15]

The three approaches for conventional tilted implants:

I. **The All in 4 concept**

Paulo Malo developed the "All-on-4® "treatment concept merging straight and angled multi-unit abutments, to provide edentulous patients with an immediately loaded full-arch restoration with only four implants. Two placed vertically in the anterior region and two placed in the posterior region with a 45° angulation.

Literature Review: A systematic review that shortlisted 24 articles based on the selection criteria reported a survival rate of 99.8% after 2 years of follow up. The study adds biological complications were seen in a few patients after a mean follow-up of two years.[15]

Another research which reported 4804 implant cases, reported 74 failed implant cases. 74% of the failed cases were reported within the first year of implant placement. An average bone loss of 1.3 ± 0.4 mm was reported after 3 years. When comparing maxillary versus mandibular arches and axially versus tilted placed implants, the results were insignificant.[16]

II. **Columbus bridge protocol:**

Founded on the same principles as the Novum Protocol, a total of four to six implants are used here. Angled

abutments are used to offset the angles of the implants.

As per this treatment protocol, full arch, screw-retained, functionally loaded interim prosthesis can be fabricated and delivered to the patients within a day or two of implant surgery.

The Columbus Bridge Protocol was developed consistent with the following goals: maintenance of predictable implant/prosthetic treatment specifically designed for edentulous maxilla, fixed prostheses, and immediate occlusal loading. Why the name Columbus? The Italian navigator did not discover America. America existed well before, but Columbus indicated the route that allowed his society to reach them and develop its huge natural resources.

The authors who belonged to the Dept of prosthodontics, Genoa University believed that the way Columbus journey to America opened a new door of opportunities and chances for the Europeans, this protocol gave a breakthrough in the treatment of immediate implant prosthesis fabrication for the clinicians. Simply speaking, as Columbus traveled the world, and got his crew safely home; this new protocol allows the clinicians to deliver the best results in terms of predictability of the treatment, functionality, and aesthetic results and give the patients the best results as they complete the journey of finishing the treatment.

The authors believe that clinicians should possess the same curiosity and skill in preparing to treat their patients as Columbus exhibited in his desire to explore the New World.[17,18]

III. **Co-axis implants**

The correct Implant angulation is subgingival and affected by the positioning of the implant platform. Theinnovative design from Southern Implants allows oral surgeons and other dental professionals to utilize existing bone while maintaining the restorative platform at an angle that ensures an optimal aesthetic result.[17]

Bedrossian classification[19]

This classification divided the edentulous maxilla into 3 radiographic zones for systematic assessment of the residual alveolar bone available for implant placement (Figure 2)

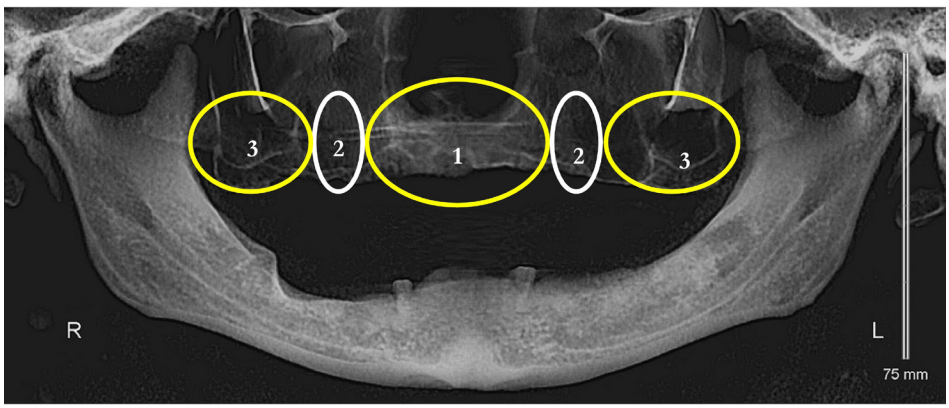

Figure 2: Zones of Bedrossian Classification – zone 1 (maxillary anterior teeth), zone 2 (premolar region) and zone 3 (molar region)

In this, the screening procedure divided the edentulous zone into 3 groups,

- the maxillary anterior teeth are designated as zone 1,
- the premolar region as zone 2,
- and the molar region as zone 3.

The availability of the residual bone is used to determine the course of treatment.

Zygomatic implants

Indications: Insufficient bone posterior to canines (bone present in zone 1 only).

At present, the are 5 approaches[20]for to Zygomatic implant placement:

I. Classical approach: Branemark 1998

II. The sinus slot approach: Introduced by Stella and Warner in 2000

III. The exteriorized approach by Migliorança et al. (2006) and is also called "extra maxillary implants" or "extra sinus zygomatic implants".

IV. The minimally invasive approach using custom-made drill guides

V. The computer-aided surgical navigation system approaches Schramm et al.

Literature review: A research paper adds"*When the maxilla is severely resorbed, the concavity formed by the ridge crest is small, and the original classical technique should be used. When maxillary resorption generates a large concavity, it would be better to exteriorize the zygomatic implant*."[20]

The article says that the externalized technique has fewer surgical steps, is less invasive, and takes less surgical time than the classical and sinus slot methods. It is put up that the utilization of the sinus slot technique together with the CT-based drilling guide would enhance the final results.

Although the technique that uses the computer-aided surgical navigation system approach may produce an improved precision in the clinical procedure, the cost factor, time factor, and technical demands make it a challenge for the future.[20]

It was bothur et al who first advocated the use of 2-3 zygomatic implants on each side.[21]

Pterygoid implants

When the bone is present only in the 1st and 2nd zone, the pterygoid implants technique is used. Here, the pterygomaxillary buttress area is used as a support for immediate loading of implants. This technique is an alternative to sinus lift procedures and hence, saves 6-8 months of the treatment phase. Post implant placement, we can deliver the temporary prosthesis in 3 days even in a severely atrophied maxilla.

GOMI defined pterygoid implants as the one that engages through maxillary tuberosity into pterygoid plates and palatine bones. The survival rate of the pterygoid implant is as high as 95%.[18,22]

Robot-Assisted Implants Surgery

Today, robot-assisted implant surgery is a reality. Robots have been increasingly used for different medical and technological designing and innovations. The precision in implant placement and prosthesis fabrication with CADCAM and computer-assisted surgical guides shifted the focus from manual placement to digital assisted automation. Robotic-assisted implant surgery furnishes software for planning and navigational guidance for instrumentation during implant surgery. It delivers haptic feedback and controls the position, depth, and angulation for implant osteotomy. [23]

However, the cost-factor-benefits of robotic surgery in implant dentistry make it looks minuscule and insignificant compared to any other alternative.

Implant placement at infected sites.[24]

The decision for implant placement in infected sites is still at issue. While some contemplate implant placement in sites of chronic apical infections as a contraindication, it has been put forward that chronic lesions don't affect implant longevity.

Animals and humans have shown that immediate implants placed into infected post-extraction sockets are predictable procedures with close to 92% success rates. In cases where ridgepreservation and hard & soft tissue enhancement is required, IIP has shown success.[25] (Flowchart)[24]

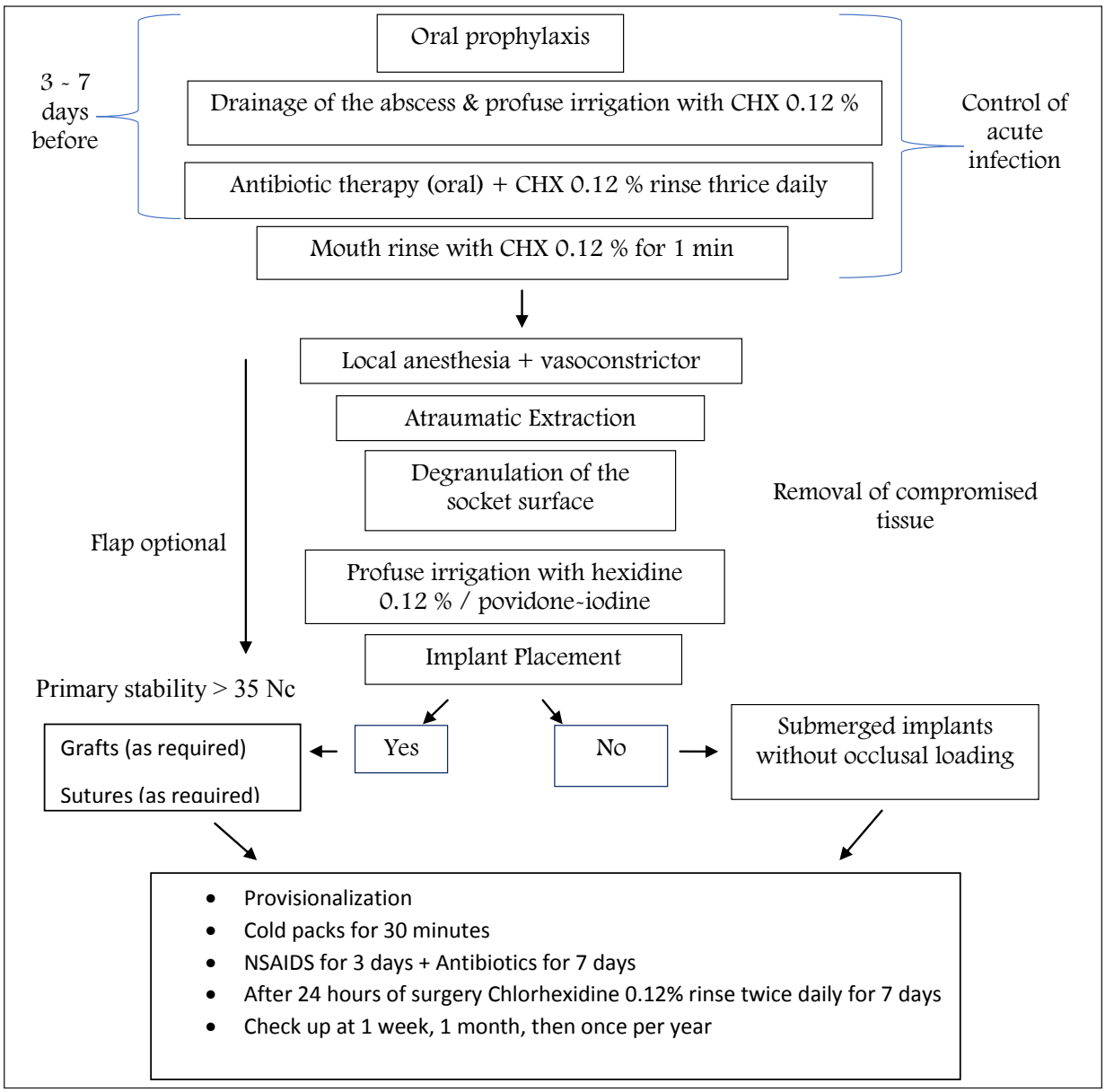

Figure 3: Protocol for immediate implant placement and provisionalization in an infected socket[24]

Classification of Compromise Rate associated with an implant (CRAI) in contact with previously infected tissue (Table 1)[24]

CRAI 0 indicates there is no compromise of the implant surface;

CRAI I, apicoronal exposure of implant that affects one wall in a percentage,50%;

CRAI II, apicoronal exposure of implant that affects one wall in a percentage of ≥50%;

CRAI III, apicoronal exposure that affects 2 or more walls in a percentage,50%; CRAI IV, apicoronal exposure that affects 2 or more walls in a percentage ≥50%.

Literature Review: Systematic reviews and metanalysis comparing infected and non-infected sites reported statistically insignificant differences.[26,27]A >95% success rate was reported by a cohort study.[28]

Implant placement at failed implant sites

The risk of implant failure depends on multiple factors, biomechanical complications is one of the major causes.

The common methods for retrieval of failed implants are trephine bur, bur–forceps (BF), neo bur–elevator–forceps (BEF), trephine drill (TD), high torque wrench (HTW), and scalpel–forceps (SF), electrosurgery (i.e., thermal explant), and the latest fixture removal kit. The most routinely used technique to remove failed implants is with the implant removal kit.[29,30]

Literature review:A total of six cases has been reported in the literature concerning the success of implants replacing failed implants at the same site.[31-36]When a commercially pure titanium screw-shaped implant is lost, a flap primarily covers the site of the entrance for 9 to 12 months, which is later replaced by a new implant of greater diameter.[37]

Authors suggested that a 1-year healing period may not be necessary, provided that the socket can be prepared to eliminate thread grooves and invasive soft tissue, the replacement implant is larger in diameter than the original implant, and sufficient available bone remains for the procedures.[37]

Recently, Alsaadi et al. compared the failure rates of implants with either a machined surface or an increased oxide layer surface used to replace failing implants. In his study, Six of the 29 machined-surface implants replaced by implants with the same surface failed (79.4% survival rate),

Table 1: Classification of Compromise Rate Associated to implant (CRAI) in contact with previously infected tissue.[24]

CRAI	% of surface compromised of implant
0	0%
I	1 Face < 50 %
II	1 Face ≥ 50 %
III	2+ Faces < 50 %
IV	2+ Faces ≥ 50 %

CRAI 0 indicates there is no compromise of the implant surface; CRAI I, apicoronal exposure of implant that affects one wall in a percentage ,50%; CRAI II, apicoronal exposure of implant that affects one wall in a percentage ≥50%; CRAI III, apicoronal exposure that affects 2 or more walls in a percentage ,50%; CRAI IV, apicoronal exposure that affects 2 or more walls in a percentage ≥50%.

whereas only one of the 19 machined-surface implants replaced by increased oxide layer surface implants failed. None of the 10 increased oxide layer-surface implants replaced by implants with the same surface failed. The difference in failure rate between machined-surface replacement implants and increased oxide layer replacement implants was statistically significant.[38]

Several factors influence implant prognosis and can attribute to implant failure: length and diameter of the implant[39], implant location and bone quality[40,41], implant surface[40,42], and smoking habits[43,44]. Upon implant failure, replacement at the same site is possible after bone healing.[45] The risk of implant failure varies among patients, and dental implant failure patterns tend to cluster within subjects.[46] Therefore, a second attempt at dental implant placement should be approached cautiously.

In a study, the success and survival of implants placed at the same location after implant failure was 71% compared to the 93.1% survival rate of traditionally placed single implants in the original cohort.[47]

Conclusion: In the present day, the digitalization of radiographs and the modernization of dental instrumentation has revolutionized the treatment options for patients. A decade ago, patients weren't having many choices, when the clinician would ask them to choose between maintaining compromised teeth or to extract? But today the scenario has changed, Implants being by far one of the best alternatives to natural teeth. Not just that, the availability of options to treat a compromised arch is much more. Tilted implants have almost taken over regeneration and augmentation procedures for geriatric and compromised patients. The overall success rate is also promising.

Finally, the future of implants is going to focus more on the material, shape, and structure of the implant for better longevity, and further long-termstudies will help us to better understand and evaluate the present shortcomings, and improvise on them,

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