Restorative Emergence Profile for Single-Tooth Implants in Healthy Periodontal Patients: Clinical Guidelines and Decision-Making Strategies

Stephen J. Chu, DMD, MSD, CDT[1]
Joseph Y. K. Kan, DDS, MS[2]
Ernesto A. Lee, DMD[3]*/Guo-Hao Lin, DDS, MS*[4]
Leila Jahangiri, BDS, DMD, MMSC[1]
Myron Nevins, DDS[5]*/Hom-Lay Wang, DDS, MS, PhD*[6]

The peri-implant soft tissue seal consists of a connective tissue cuff and a junctional epithelium that is different from the arrangement of periodontium around a natural tooth. However, the peri-implant soft tissue complex lacks Sharpey's fibers, thus offering less resistance to clinical probing and biofilm penetration compared to the natural dentition. Therefore, the proper restorative emergence profile design is essential to facilitate favorable esthetic outcomes and maintain peri-implant health. The aim of this article is to review the currently available evidence related to the design of subgingival (critical and subcritical) and supragingival contours of the implant restorative emergence profile (IREP) as well as provide a flowchart for decision-making in clinical practice. Theoretically, the subgingival contours of the crown/abutment complex should mimic the morphology of the root and the cervical third of the anatomic crown as much and as often as possible. However, this is highly dependent upon the three-dimensional spatial position of the implant relative to the hard and soft tissue complex, in addition to the location of the definitive restoration. Frequently, a convex critical contour is required on the facial aspect of a palatally or incisally positioned implant to support an adequate gingival-margin architecture. Conversely, if the implant is placed too far facially, then a flat or concave contour is recommended. In instances where soft tissue support is not needed, the subcritical area may be undercontoured to increase the thickness, height, and stability of the soft tissue cuff. Int J Periodontics Restorative Dent 2020;40:19–29. doi: 10.11607/prd.3697

[1]Department of Prosthodontics, College of Dentistry, New York University, New York, New York, USA.
[2]Department of Restorative Dentistry, School of Dentistry, Loma Linda University, Loma Linda, California, USA.
[3]Private Practice, Bryn Mawr, Pennsylvania, USA.
[4]Department of Orofacial Sciences, School of Dentistry, University of California, San Francisco, California, USA.
[5]Department of Oral Medicine, Infection, and Immunity, Harvard School of Dental Medicine, Boston, Massachusetts, USA.
[6]Department of Periodontics & Oral Medicine, School of Dentistry, University of Michigan, Ann Arbor, Michigan, USA.

Correspondence to: Dr Stephen J. Chu, Ashman Department of Periodontology and Implant Dentistry, 150 E. 58th Street, Suite 3200, New York, NY 10155, USA. Fax: (212) 754-6753. Email: schudmd@gmail.com

Submitted December 18, 2017; accepted January 16, 2018.

The restorative emergence profile (REP) is defined as "tooth and crown contour as they traverse soft tissues and rise toward the contact area interproximally and height of contour facially and lingually."[1] On a natural tooth, it represents the contour of a tooth or restoration as it emerges from the gingiva. In the case of an implant-supported restoration, the implant restorative emergence profile (IREP) represents the contour of the implant abutment/crown complex as it arises from the implant restorative platform and emergence from the peri-implant soft tissues.

Ideally, the IREP contour should mimic that of the extracted tooth while supporting a harmonious, esthetic gingival architecture that mimics the surrounding natural dentition from a level (facial and proximal) and morphologic standpoint.[2] Unfortunately, the presence of an implant, even if it was correctly placed, in conjunction with possible bone and soft tissue grafting procedures, will induce biologic changes that alternate the dynamics of the peri-implant gingiva (gingival thickness; horizontal and vertical contour). Therefore, to achieve an esthetic implant gingival architecture that emulates that of the contralateral tooth, the IREP contour often requires significant modification and customization, which may not be as simplistic as mimicking the natural anatomy of

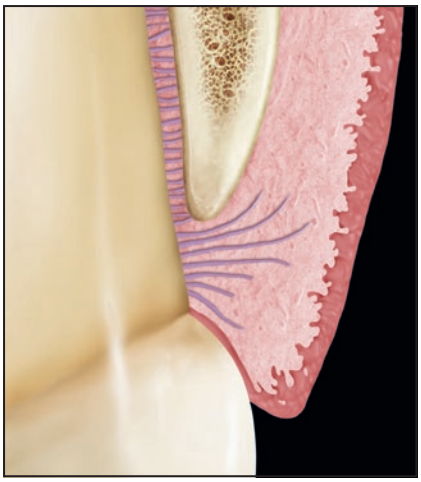


Fig 1 *The REP should mimic the contours of a healthy natural tooth. The attachment of the gingival connective tissue fibers to the root surface provides stability to the gingival complex. The cervical contour of the anatomical crown within the gingival sulcus provides support for the unattached soft tissue and determines the architecture of the gingival margin.*

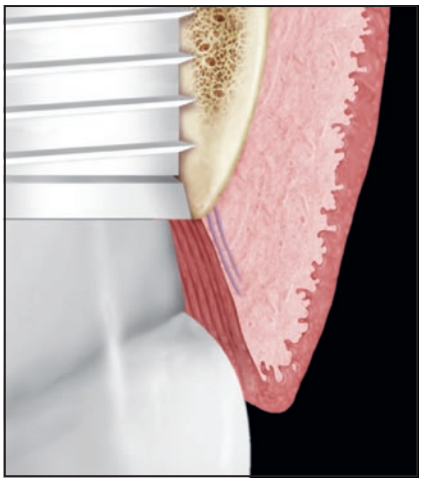


Fig 2 *The IREP should match that of the natural tooth provided the implant platform is placed concentrically relative to the clinical crown of the restoration. The critical contour of the restoration is a zone that is 1 to 2 mm below the free gingival margin, coincident with the anatomical crown and CEJ of the implant restoration. The subcritical contour extends apically from the critical contour area to the implant platform.*

the corresponding tooth. This variability in customization makes it difficult to establish concrete guidelines for the ideal IREP contour, which is reflected in the lack of consensus in the literature.

The aim of this article is to review the currently available evidence related to the design of contours of the IREP, as well as provide recommendations and a decision tree for clinical practice and reference with consideration of the dental implant position, which may be the most significant factor affecting IREP.

Definition

Implant restorative contour (or emergence profile) in its most simplistic approach and perspective is the three-dimensional (3D) shape of the sub- and supragingival contours to maximize the esthetic appearance of the definitive restoration and allow proper oral hygiene. This process and procedure are highly dependent upon the 3D spatial location of the implant.

The subgingival contour can be subdivided into two categories: subcritical and critical. The subcritical contour is analogous to the tooth root surface above the osseous crest, both facially and interproximally, where the connective tissue Sharpey's fibers are inserted into the cementum, perpendicular to the long axis of the tooth (Fig 1). The subcritical contour is an area located immediately coronal to the implant platform that extends to the critical contour, or cementoenamel junction (CEJ), of the tooth or restoration (Fig 1). The apico-coronal dimension varies depending on the level or depth at which the implant is placed. Whenever possible, the subcritical contour should provide a gradual and harmonious transition from the implant platform to the critical contour. This, however, requires that sufficient "running room," or implant depth, is present between the crest of the soft tissue gingiva and the implant platform. Limited information is available to define the adequate amount of "running room," since it is a dynamic algorithm dependent on implant position and angulation (Fig 2).[3] This can be further complicated with the use of platform-switched abutment-implant connections. By design, these connections are smaller in diameter relative to the implant interface, therefore requiring greater implant depth for a more gradual REP.

The subcritical contour may be designed from the implant platform to the critical contour area following a straight, concave, or convex profile[4]; the palatal or facial implant position and angulation determine the general orientation of the subcritical area. It can be overcontoured (convex) to support the gingival tissue, if needed, or undercontoured (concave) to decrease pressure to the facial gingiva and/or increase the thickness of the peri-implant soft tissues.[5] Similar considerations apply to mesio-distal variations in implant placement. Steigmann et al[5] proposed a guideline to address the abutment-prosthesis design based on implant position and angulation. If the implant is placed in a palatal

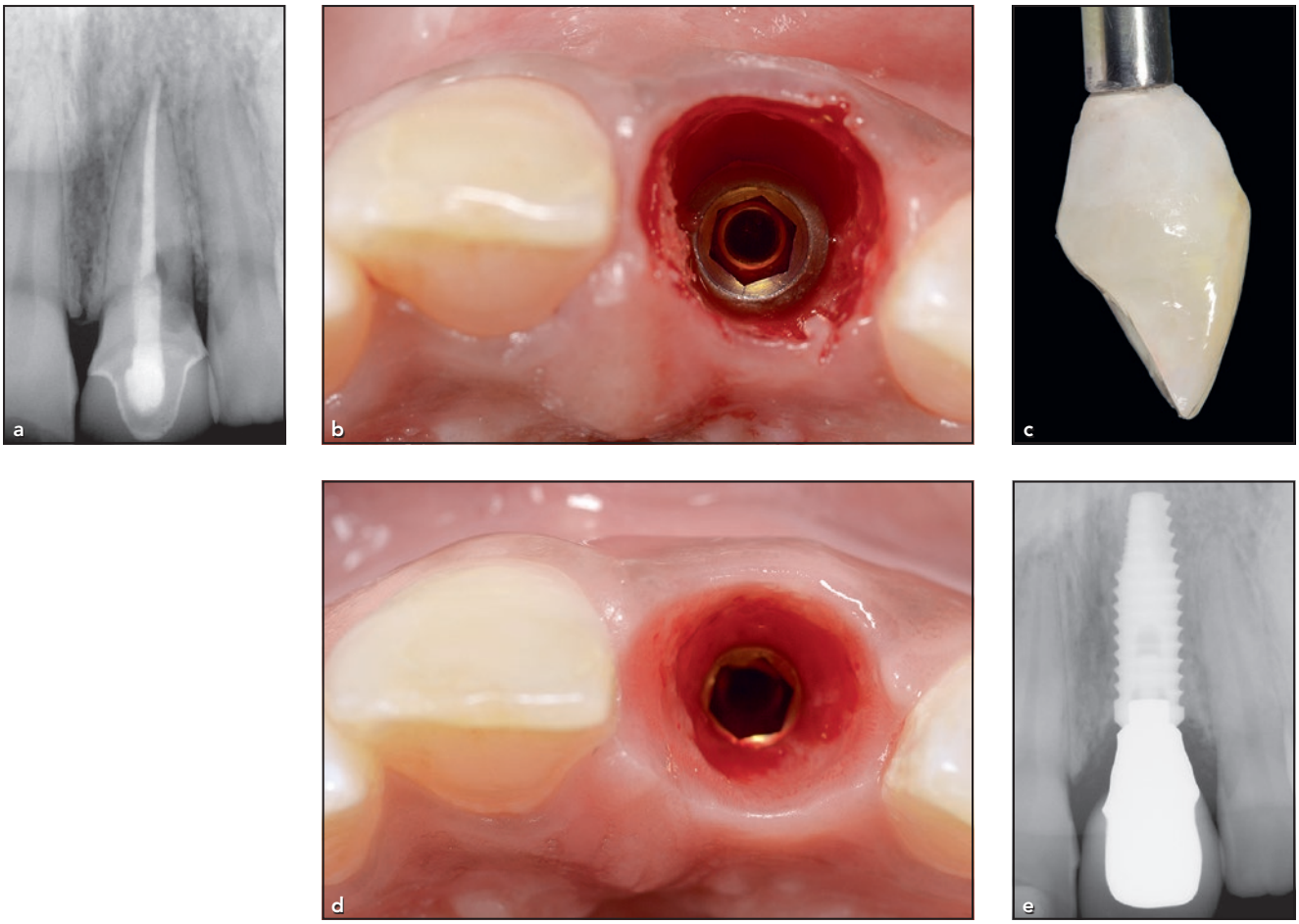


Fig 3 (a) *Periapical radiograph of a patient requiring implant replacement of the maxillary left central incisor due to a resorption lesion in the distal aspect of the tooth.* (b) *The implant was placed toward the palatal aspect of the extraction socket.* (c) *The provisional restoration was constructed with convex facial subcritical contour to support the existing tissues with palatal implant placement.* (d) *The labial peri-implant soft tissues need support after healing to maintain the free gingival margin and zenith in the correct position.* (e) *The final radiograph shows the gradual interproximal supportive contours of the metal-ceramic screw-retained crown restoration.*

location, a convex contour at the facial side should be used to support the marginal soft tissues (Fig 3). Additionally, Cooper[6] suggested that a slightly concave contour should be used at the interproximal areas to minimize excess pressure and the potential for resorption of the adjacent bone. Similarly, several studies have warranted the use of a concave subcritical contour at the facial aspect if the implant is placed in a labial-incisal position (Fig 4).[7–10] Rompen et al[10] analyzed an experimental abutment with a concave subcritical contour and showed an absence of peri-implant soft tissue recession in 87% of the cases after 2 years of definitive restoration. Therefore, a concave subcritical contour should always be considered if the implant location is in a facial position or angulation.[5] It is often recommended to have a concave subcritical profile at the midfacial location and concave or straight contour in the interproximal areas to allow more soft tissue in-growth, even though the height of the interdental papilla is a function of the interproximal attachment level in the adjacent natural teeth.[11–13] The only exception is if there is a need to support the soft tissues facially; then a convex subcritical contour at the facial side will be indicated.

The critical contour is also subgingival in relation to the free gingival margin (FGM), represented by the CEJ location or transition zone

Fig 4 (a) *A patient with a high smile line presented with midfacial gingival recession due to excessive labial angulation and placement of the maxillary left central incisor implant.* (b) *Excessive abutment contour is a secondary consequence of poor implant position, which puts pressure on the peri-implant soft tissues and results in recession.* (c) *After correcting the soft tissues, the new abutment is designed with straight or concave subcritical facial contour.* (d) *The new zirconia abutment, seated with the proper contour that allows correct positioning of the free gingival margin.* (e) *Extraoral view of the definitive restoration 8 years after initial placement, showing stability of the gingival margins with the correct IREP.*

between the tooth root surface and the anatomical crown. It is not uncommon that this contour is convex relative to the tooth root surface and can support the FGM location or zenith in the proper position. The critical contour is defined as an area extending from the FGM 1.0 to 1.5 mm apically. It is present circumferentially and determines the gingival margin level, architecture, and thus the cervical morphology of the clinical crown. Since the final restoration should mimic the contralateral tooth in health, the ideal critical contour cannot be compromised in this regard and must be developed to support the final esthetic

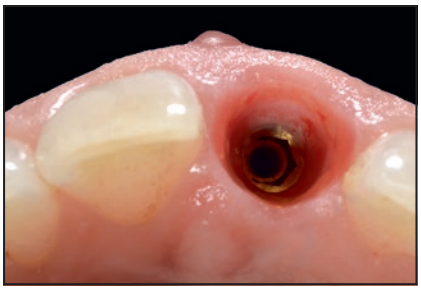


Fig 5 *In another patient, an implant was placed at the maxillary left central incisor site, 3.0 to 4.0 mm apically from the soft tissue crest and slightly palatal to a line bisecting the buccolingual position of the final restoration with a cingulum sagittal angulation.*

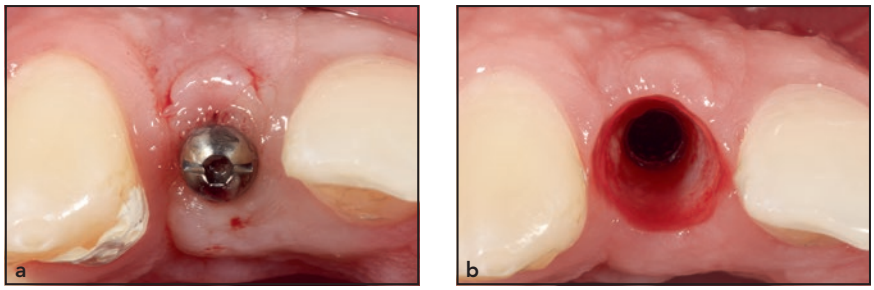


Fig 6 (a) *An implant was placed in a single-stage procedure with a stock healing abutment to replace the maxillary right lateral incisor, but* (b) *the abutment does not provide the proper IREP. Therefore, before impression-making, a custom provisional restoration is used to nonsurgically sculpt the peri-implant soft tissues properly.*

outcome, regardless of implant position.[4] In cases of inadequate implant depth or pre-existing gingival recession, the critical contour of the definitive restoration may be supra- or equigingival, coincident with the clinical crown.

Lastly, the design of critical and subcritical contours should be the same for both cement- and screw-retained implant restorations.

Ideal Implant Position

Unfortunately, there is little consensus on the spatial position of a dental implant. However, Grunder et al[14] recommended that there be at least 2.0 mm of bone facial to the surface of the implant; Linkevicius et al[15] recommended 2.0 to 3.0 mm of vertical tissue thickness or implant depth over the implant-abutment interface. These concepts are universal to immediate (postextraction socket) and delayed (healed or augmented ridge) implant sites, as well as cement- and screw-retained restorations. Even though cement-retained restorations have recently fallen out of favor due to the potential risk of iatrogenic peri-implantitis (peri-cementitis) from residual cement and irretrievability of the restoration, techniques have been developed to solve this issue.[16] Therefore, the ideal implant position would be: *(1)* 3.0 to 4.0 mm in a corono-apical position from the soft tissue crest; *(2)* slightly palatal to a line that bisects the buccolingual position of the final restoration with a cingulum sagittal angulation; and *(3)* bisecting the mesio-distal space with at least 1.5 mm between the implant and adjacent teeth (Fig 5).

Ideal Design of IREP

An ideally designed single-implant REP supports a harmonious gingival architecture with the surrounding dentition from level (facial and proximal) and shape standpoints.[2] The ideal design is a bit of a misnomer since it is specific and custom for each individual implant placement, and two are rarely identical. The subcritical contour of the abutment-restoration should be biologically acceptable without impinging on the osseous crest circumferentially, since the re-establishment of the biologic width is part of the wound-healing process.[2] Additionally, an overcontoured subcritical area could cause gingival recession or loss of papilla height. Conversely, subcritical undercontour may lead to thickening of the peri-implant soft tissue.[12] Notwithstanding, it may also result in a poor esthetic appearance if there is lack of proper midfacial subgingival support, leading to the collapse of peri-implant soft tissues. A more natural and hygienic REP can be achieved when the implant is placed in the optimal 3D position. In addition, when stock healing abutments are used in a single-stage implant protocol, the soft tissues can be nonsurgically sculpted with the provisional restoration prior to impression-making (Fig 6).[17]

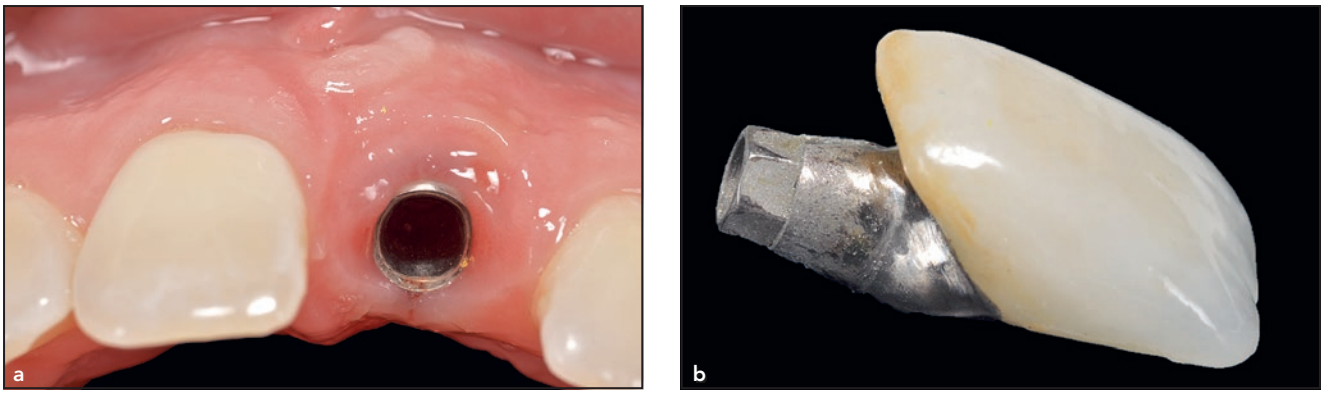


Fig 7 (a) *A maxillary left central incisor implant was placed equigingivally and thus posed a significant challenge for the restorative dentist to achieve an esthetic outcome.* (b) *An implant crown restoration with a ridge-lap design was used due to the non-ideal implant position. This poses a problem in hygiene maintenance for both the patient and clinician alike.*

Interdental IREP

As previously mentioned, the interproximal restorative contours should not place excessive pressure on the surrounding soft tissues. Doing so, whether intentionally or inadvertently, can cause pain and unwanted bone resorption. A series of studies were conducted by Patil et al[18–20] to compare the effect of concave profile abutments and conventional straight abutments on the papillary fill of single-implant restorations. There was no significant difference in terms of patients' satisfaction, pink esthetic scores,[21] or soft tissue stability between the two abutment shapes. The findings provide evidence that either a straight or concave subcritical contour could be used at the interproximal sites. On the other hand, a case series by Redemagni et al[9] reported a tendency for papilla loss with divergent subcritical contour due to pressure on and ischemia to the soft tissues. Therefore, the use of a subcritical convex design at the interproximal area should be approached with caution.

Factors Affecting IREP

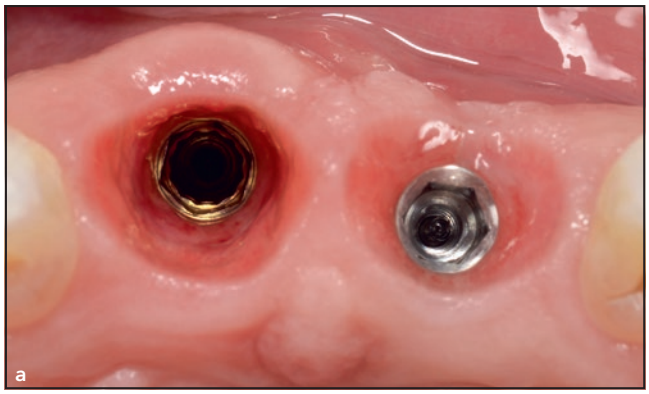
There are two critical factors that can affect the shape of the IREP: *(1)* vertical soft tissue dimension or implant depth, and *(2)* horizontal soft tissue dimension (periodontal phenotype or biotype) or thickness.

Vertical Soft Tissue Dimension (VSTD)

The peri-implant soft tissue complex is similar to the dentogingival complex in that both possess a vertical dimension of 3.0 mm, consisting of a sulcus, junctional epithelium, and connective tissue.[22] This is not always the clinical situation in a healed ridge, since there is only biologic width; the sulcus depth is not present due to the absence of a tooth or restoration.

Even with proper VSTD, the biggest difference lies upon the quality of the connective tissue attachment, where there is no perpendicular fiber insertion but a network of parallel/circumferential fibers that is structurally similar to scar tissue around dental implants. Because of this, the peri-implant soft tissues offer less resistance to clinical probing and biofilm penetration compared to natural teeth.[23] Also, in an animal study, the development of biologic width depends on the level of implant placement in relation to the bone crest.[24] An implant placed subcrestally (> 3.0 mm) may result in additional bone remodeling above the implant-abutment junction and increased probing depth, which may pose a challenge for maintaining the stability of peri-implant soft tissues.[25] Since this tissue complex has a greater risk around dental implants due to the lack of connective fiber attachment, an ideally designed IREP may play a critical role in enhancing soft tissue quality and quantity while further facilitating esthetic outcomes. A laser-microtextured–finished implant or abutment has demonstrated a physical connective tissue attachment that prevents apical migration of the epithelium. This then protects the cervical level of bone.[26,27]

The lack of implant depth and/or vertical soft tissue thickness



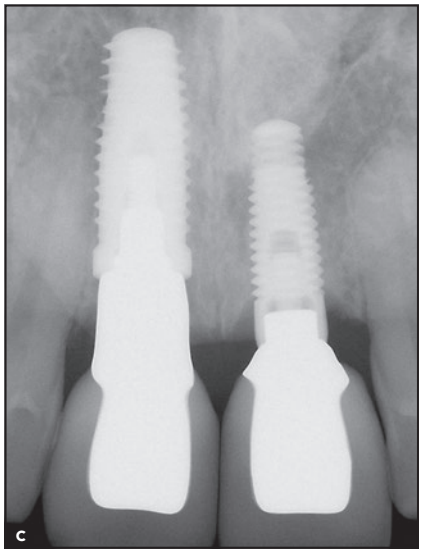


Fig 8 (a) *A dental implant for tooth 11 was placed at an ideal implant position, 3 to 4 mm apical to the adjacent CEJ; however, an implant for tooth 21 was placed relatively shallow and with insufficient vertical depth for tissue support.* (b) *For the implant at site 11* (right)*, the subcritical contour was designed slightly concave with a smooth junction between critical and subcritical contours. On the contrary, the subcritical contour of the implant at site 21* (right) *was overcontoured to compensate for its shallow position.* (c) *Radiographic comparison of the subcritical contour between the definite restorations at sites 11 and 21. Note the slightly concave design and smooth junction for the site-11 restoration and the overcontoured design for the site-21 restoration.*

poses a significant challenge to the restorative dentist, as the contours are usually less than ideal and hygiene becomes difficult if not perplexing. When the implant-abutment interface is equi- or supragingival in the esthetic zone, the only restorative solution is a ridge-lap design of the implant-crown restoration (Fig 7). This design presents challenges to the patient and clinician alike, as performing proper oral hygiene becomes difficult both at home and professionally. When the implant depth is still shallow at 1.0 to 1.5 mm below the FGM, the IREP is overcontoured both facially and interproximally in order to mimic proper tooth form and shape of the contralateral tooth (Fig 8). This overcontour can also pose obstacles to proper oral hygiene performance.

Horizontal Soft Tissue Dimension (HSTD)

Restorative management of horizontal soft tissue thickness relative to implant placement, whether in a postextraction socket or a healed or augmented ridge, is a clinical challenge that all restorative dentists face. The amount of HSTD is also a function of spatial implant position and depth. The horizontal width of the dentogingival complex around a natural tooth is roughly 1.0 to 1.5 mm in thickness, measured 1.0 to 2.0 mm from the FGM.

With the advent of screw-retained implants and intentional palatal positioning, the horizontal thickness of facial tissue may be > 2.0 mm, thus requiring a convex contour to support the gingiva in the proper position. The converse is true for implants positioned or angulated too far facially, where the HSTD is thin (less than 1.0 mm thick).[28] In these

situations, a flat or concave contour (undercontour) is required to omit or minimize labial pressure on the peri-implant soft tissues, thereby allowing them to migrate in a more coronal position. It is common that facially placed or angulated implants require cement-retained restorations with angle correction and a custom abutment and crown.

HSTD can be influenced by periodontal phenotype (biotype) and be enhanced during postextraction socket treatment with immediate implant and tooth-replacement therapies. One such technique described by Chu et al[29] compared four different surgical/restorative techniques (a conventional flat healing abutment as the control, an immediate anatomical restoration without grafting materials, a conventional healing abutment with a grafting procedure, and an immediate anatomical restoration with bone grafting procedure), and analyzed the outcomes of facial-palatal ridge dimension and shape (collapse) and the peri-implant soft tissue thickness. The results showed that placing a bone allograft with an anatomical provisional restoration reduces facial-palatal ridge collapse to less than 0.2 mm and increases peri-implant soft tissue dimensions by 0.5 to 1.0 mm compared to the control. This study provides evidence for the dual-zone technique[30] and further warrants the concept that the peri-implant tissue framework should mimic the shape of the anatomical root whenever possible.

Similar to the dual-zone technique,[30] one study[31] analyzed the design of the emergence profile for single molar replacement. This technique recommended using a straight profile for the first 1.0 mm of the supracrestal portion of the abutment, thus designing a subcritical undercontour immediately coronal to the implant platform. The space provided would provide bone graft isolation and stabilization. At the midbuccal portion, a slightly rounded circumferential margin and gentle slope of 0.5 mm below the FGM were also recommended. Interproximally, a flat or straight surface with a slightly divergent profile was used to provide papillary support. Rarely should a convex subcritical contour be used interproximally in the anterior region.

During fabrication of an implant-supported provisional crown immediately after implant placement, a temporary cylinder and resin-based materials are often used to develop the ideal REP.[30,32] Several techniques have been introduced to contour the peri-implant soft tissue during implant healing, including (but not limited to) divergent healing abutments, customized abutments, provisional restorations, etc.[30,33] Of these options, transitional custom abutments and provisional crowns provide the flexibility to add or subtract restorative materials and idealize the REP.[33–35] In addition, when compared to circular-shaped healing abutments, an anatomical-shaped provisional crown could potentially increase soft tissue support because of its ability to mimic the cross-sectional form of the root.[36] Hence, it has been suggested to utilize screw-retained provisional crowns whenever possible and eliminate the risk of residual cement in the gingival sulcus postextraction, which would interfere with healing.[37–39]

In addition, the use of platform-switched implant-abutment designs can also increase horizontal soft tissue thickness due to the horizontal offset in the prosthetic diameter. Platform-switched designs offer an advantage in subcritical contours since the reduced diameter places little if any pressure on the surrounding bone and soft tissues.

Decision Tree

Based on the available evidence and clinical experience, a decision tree was made to illustrate the design of critical and subcritical contours (Fig 9), proposed for clinical reference. Critical contour should be consistent circumferentially from the FGM to approximately 1.5 mm apically. Since it determines the gingival margin architecture and thus the esthetic outcome, the critical contour should be ideally developed to mimic the contralateral tooth, regardless of implant position. The critical contour is usually convex, following the cervical morphology of the anatomical crown. The degree of convexity will vary depending on implant position. The use of a straight or concave critical contour profile may be required in cases of excessive labial implant placement or angulation. Additionally, if the gingival biotype is thick and does not require support, a concave subcritical contour may be used to enhance peri-implant tis-

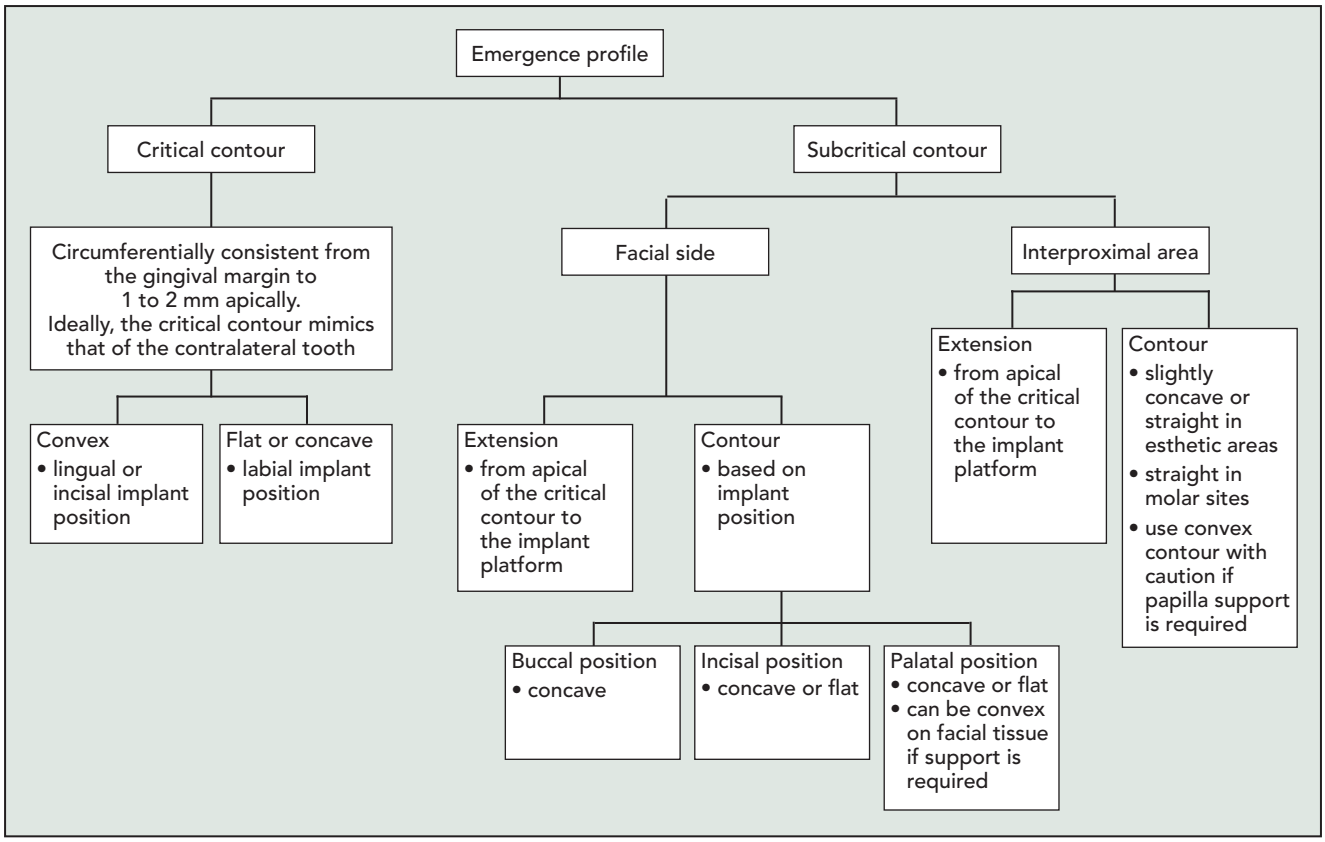


Fig 9 *A decision tree illustrating the ideal design of critical and subcritical contours of emergence profiles.*

sue thickness. However, when a thin gingival biotype is present, soft tissue support is often necessary and a convex subcritical contour may be indicated on the labial surface.

The subcritical contour extends from the implant platform to the base of the critical contour. It should be straight and flat with a vertical extension of 0.5 to 1.0 mm; its apicocoronal dimension varies depending on the depth of implant placement. Implant position and angulation have the greatest effect on the design of midfacial subcritical contour. Ideally, the contour should be flat or concave for a facially positioned implant, slightly convex to flat for an incisally positioned implant, and convex for a palatally positioned implant. Interproximally, the subcritical contour is slightly concave or straight in the esthetic zone. In some rare occasions, a convex subcritical contour may be used if papillary support is required.

Subcritical contour modifications require an adequate amount of running room, which is dependent on implant position. Limited running room may result in an REP that needs to transition abruptly from the ideal critical contour to the implant platform. In some instances, a connective tissue graft might be required to convert the gingival phenotype from thin to thick for the purpose of enhancing esthetics.

Conclusions

Based on the currently available literature, a lack of convincing evidence is noted in terms of the ideal REP design. Theoretically, the critical and subcritical contours of the crown/abutment complex should mimic the anatomical tooth/root shape as much as possible to provide adequate tissue support; however, REP is highly dependent upon implant position and periodontal phenotype. The proposed decision tree provides a guideline for clinicians to design the ideal critical and subcritical contours of single-tooth implant restorations to achieve optimal esthetic outcomes.

Acknowledgments

The authors do not have any direct financial interests in the products or information listed in the paper.

References

1. Stein RS, Kuwata M. A dentist and a dental technologist analyze current ceramo-metal procedures. Dent Clin North Am 1977;21:729–749.
2. Schoenbaum TR, Swift EJ Jr. Abutment emergence contours for single-unit implants. J Esthet Restor Dent 2015;27:1–3.
3. Potashnick SR. Soft tissue modeling for the esthetic single-tooth implant restoration. J Esthet Dent 1998;10:121–131.
4. Su H, Gonzalez-Martin O, Weisgold A, Lee E. Considerations of implant abutment and crown contour: Critical contour and subcritical contour. Int J Periodontics Restorative Dent 2010; 30:335–343.
5. Steigmann M, Monje A, Chan HL, Wang HL. Emergence profile design based on implant position in the esthetic zone. Int J Periodontics Restorative Dent 2014; 34:559–563.
6. Cooper LF. Objective criteria: Guiding and evaluating dental implant esthetics. J Esthet Restor Dent 2008;20:195–205.
7. Iglhaut G, Schwarz F, Winter RR, Mihatovic I, Stimmelmayr M, Schliephake H. Epithelial attachment and downgrowth on dental implant abutments--a comprehensive review. J Esthet Restor Dent 2014;26:324–331.
8. Nam J, Aranyarachkul P. Achieving the optimal peri-implant soft tissue profile by the selective pressure method via provisional restorations in the esthetic zone. J Esthet Restor Dent 2015;27:136–144.
9. Redemagni M, Cremonesi S, Garlini G, Maiorana C. Soft tissue stability with immediate implants and concave abutments. Eur J Esthet Dent 2009;4: 328–337.
10. Rompen E, Raepsaet N, Domken O, Touati B, Van Dooren E. Soft tissue stability at the facial aspect of gingivally converging abutments in the esthetic zone: A pilot clinical study. J Prosthet Dent 2007;97(suppl 6):s119–s125.
11. Grunder U. Stability of the mucosal topography around single-tooth implants and adjacent teeth: 1-year results. Int J Periodontics Restorative Dent 2000;20:11–17.
12. Kan JY, Rungcharassaeng K, Lozada JL, Zimmerman G. Facial gingival tissue stability following immediate placement and provisionalization of maxillary anterior single implants: A 2- to 8-year follow-up. Int J Oral Maxillofac Implants 2011;26:179–187.
13. Kois JC. Predictable single-tooth peri-implant esthetics: Five diagnostic keys. Compend Contin Educ Dent 2004;25: 895–898.
14. Grunder U, Gracis S, Capelli M. Influence of the 3-D bone-to-implant relationship on esthetics. Int J Periodontics Restorative Dent 2005;25:113–119.
15. Linkevicius T, Puisys A, Linkeviciene L, Peciuliene V, Schlee M. Crestal bone stability around implants with horizontally matching connection after soft tissue thickening: A prospective clinical trial. Clin Implant Dent Relat Res 2015; 17:497–508.
16. Wadhwani C, Pineyro A. Technique for controlling the cement for an implant crown. J Prosthet Dent 2009;102:57–58.
17. Zamzok J. Avoiding ridge laps through nonsurgical soft tissue sculpting on implant restorations. J Esthet Restor Dent 1996;8:222–228.
18. Patil R, den Hartog L, Dilbaghi A, de Jong B, Kerdijk W, Cune MS. Papillary fill response in single-tooth implants using abutments of different geometry. Clin Oral Implants Res 2016;27:1506–1510.
19. Patil R, Gresnigt MMM, Mahesh K, Dilbaghi A, Cune MS. Esthetic evaluation of anterior single-tooth implants with different abutment designs-patients' satisfaction compared to dentists' observations. J Prosthodont 2016; 26:395–398.
20. Patil R, van Brakel R, Iyer K, Huddleston Slater J, de Putter C, Cune M. A comparative study to evaluate the effect of two different abutment designs on soft tissue healing and stability of mucosal margins. Clin Oral Implants Res 2013; 24:336–341.
21. Fürhauser R, Florescu D, Benesch T, Haas R, Mailath G, Watzek G. Evaluation of soft tissue around single-tooth implant crowns: The pink esthetic score. Clin Oral Implants Res 2005;16:639–644.
22. Cochran DL, Hermann JS, Schenk RK, Higginbottom FL, Buser D. Biologic width around titanium implants. A histometric analysis of the implanto-gingival junction around unloaded and loaded nonsubmerged implants in the canine mandible. J Periodontol 1997;68: 186–198.
23. Schou S, Holmstrup P, Stoltze K, Hjørting-Hansen E, Fiehn NE, Skovgaard LT. Probing around implants and teeth with healthy or inflamed peri-implant mucosa/gingiva. A histologic comparison in cynomolgus monkeys (Macaca fascicularis). Clin Oral Implants Res 2002; 13:113–126.
24. Huang B, Meng H, Piao M, Xu L, Zhang L, Zhu W. Influence of placement depth on bone remodeling around tapered internal connection implant: A clinical and radiographic study in dogs. J Periodontol 2012;83:1164–1171.
25. Hermann JS, Jones AA, Bakaeen LG, Buser D, Schoolfield JD, Cochran DL. Influence of a machined collar on crestal bone changes around titanium implants: A histometric study in the canine mandible. J Periodontol 2011;82: 1329–1338.
26. Nevins M, Nevins M, Gobbato L, Lee HJ, Wang CW, Kim DM. Maintaining interimplant crestal bone height via a combined platform-switched, Laser-Lok implant/abutment system: A proof-of-principle canine study. Int J Periodontics Restorative Dent 2013;33:261–267.
27. Nevins M, Nevins ML, Camelo M, Boyesen JL, Kim DM. Human histologic evidence of a connective tissue attachment to a dental implant. Int J Periodontics Restorative Dent 2008;28:111–121.
28. Rungcharassaeng K, Kan JY, Yoshino S, Morimoto T, Zimmerman G. Immediate implant placement and provisionalization with and without a connective tissue graft: An analysis of facial gingival tissue thickness. Int J Periodontics Restorative Dent 2012;32:657–663.
29. Chu SJ, Salama MA, Garber DA, et al. Flapless postextraction socket implant placement, part 2: The effects of bone grafting and provisional restoration on peri-implant soft tissue height and thickness- a retrospective study. Int J Periodontics Restorative Dent 2015;35:803–809.
30. Chu SJ, Salama MA, Salama H, et al. The dual-zone therapeutic concept of managing immediate implant placement and provisional restoration in anterior extraction sockets. Compend Contin Educ Dent 2012;33:524–532, 534.

31. Akin R. A new concept in maintaining the emergence profile in immediate posterior implant placement: The anatomic harmony abutment. J Oral Maxillofac Surg 2016;74:2385–2392.
32. Wohrle PS. Single-tooth replacement in the aesthetic zone with immediate provisionalization: Fourteen consecutive case reports. Pract Periodontics Aesthet Dent 1998;10:1107–1114; quiz 1116.
33. Lee EA. Transitional custom abutments: Optimizing aesthetic treatment in implant-supported restorations. Pract Periodontics Aesthet Dent 1999;11: 1027-1034.
34. Alani A, Corson M. Soft tissue manipulation for single implant restorations. Br Dent J 2011;211:411–416.
35. Karunagaran S, Markose S, Paprocki G, Wicks R. A systematic approach to definitive planning and designing single and multiple unit implant abutments. J Prosthodont 2014;23:639–648.
36. Bain CA, Weisgold AS. Customized emergence profile in the implant crown--a new technique. Compend Contin Educ Dent 1997;18:41–45; quiz 46.
37. Bichacho N, Landsberg CJ. Single implant restorations: Prosthetically induced soft tissue topography. Pract Periodontics Aesthet Dent 1997;9: 745–752.
38. Furze D, Byrne A, Alam S, Wittneben JG. Esthetic outcome of implant supported crowns with and without peri-implant conditioning using provisional fixed prosthesis: A randomized controlled clinical trial. Clin Implant Dent Relat Res 2016;18:1153–1162.
39. Wittneben JG, Brägger U, Buser D, Joda T. Volumetric calculation of supra-implant submergence profile after soft tissue conditioning with a provisional restoration. Int J Periodontics Restorative Dent 2016;36:785–790.