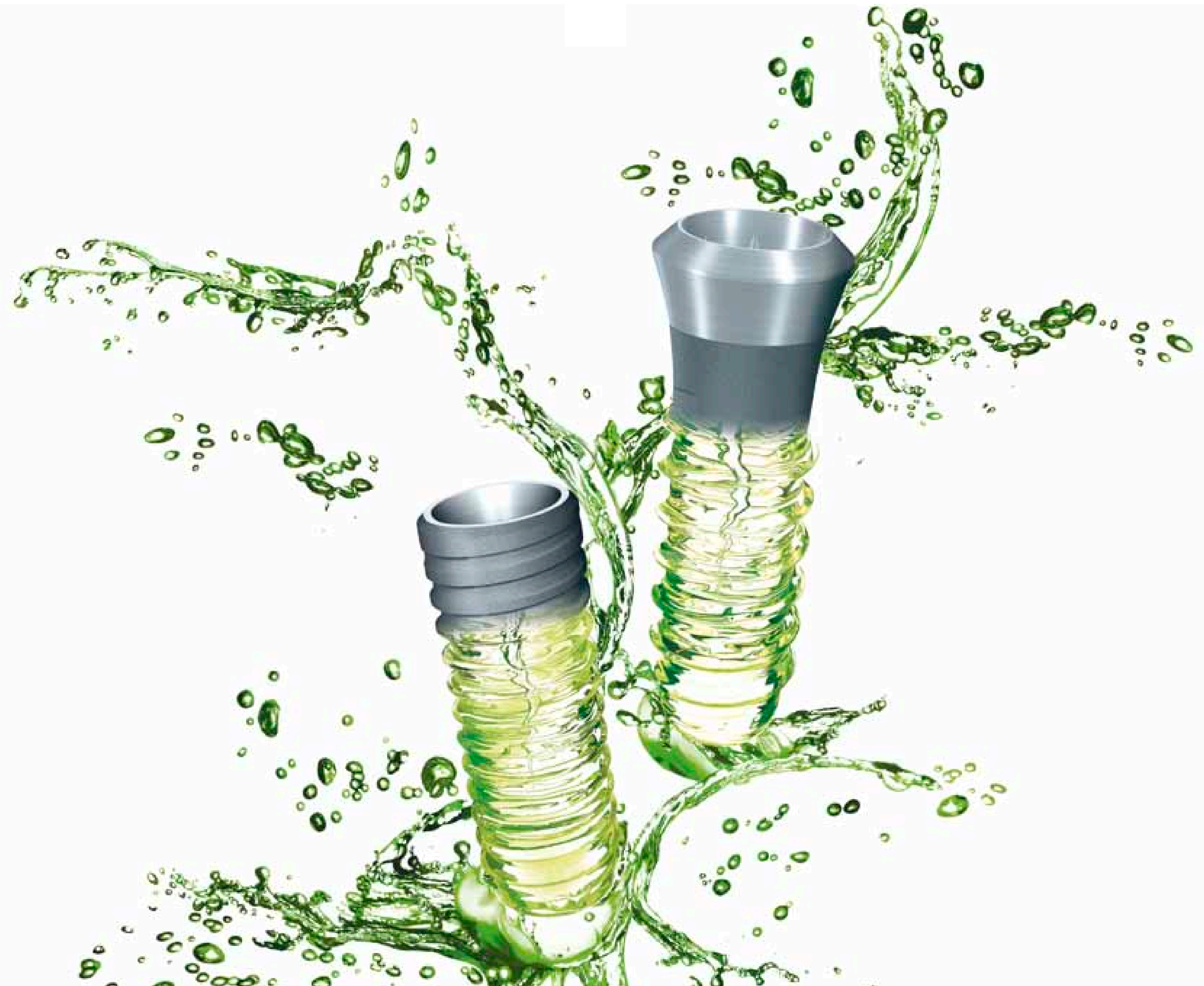
straumann

SLActive® SCIENTIFIC EVIDENCE



COMMITTED TO
SIMPLY DOING MORE℠
FOR DENTAL PROFESSIONALS

Innovation: SLActive®

The clinical challenge

In the osseointegration process, two factors play an important role: Primary stability (mechanical stability) and secondary stability (biologic stability). Taking bone quality into consideration, achievement of primary stability is predictable thanks to key features of implant system design, such as thread pitch, precision of implant dimensions, and corresponding drills.

Secondary stability is the result of the biologic healing process, and is therefore not under the direct control of the clinician. Achievement of full secondary stability is subject to numerous variables, the most significant of all being the speed of the osseointegration process. The implant surface can enhance the speed at which osseointegration occurs.

The sum of primary and secondary stability is referred to as total stability. A delay in the healing process leads to a marked decrease in the total stability of the implant between weeks 2 and 4, making this "stability dip" a critical time in the osseointegration process (Fig 1).

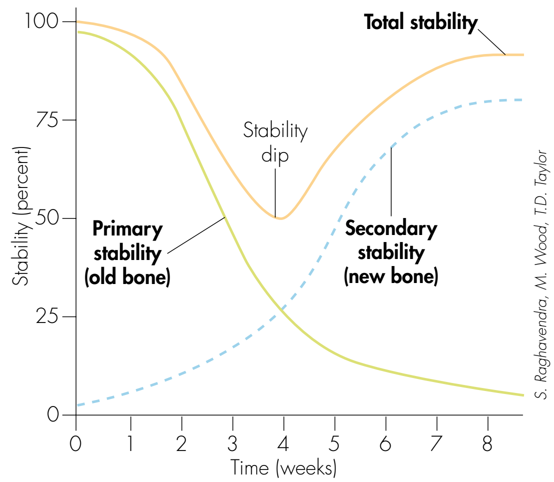


Fig. 1: *The decreasing primary stability and increasing secondary stability result in a decrease in overall stability (dip) between week 2 and 4 after implant placement.*

With this in mind, the clinician may be cautious in the selection of implant candidates and implant treatment options. This caution is noteworthy in today's market because it limits the application of stability-critical protocols such as early and immediate loading.

The innovation: "shift the dip"

The goal in the development of SLActive was to achieve secondary stability sooner by accelerating the osseointegration process. To reach this goal, researchers focused on understanding the biology behind the initial healing processes following implant placement.

The result of these inquiries is the SLActive surface. SLActive takes the scientifically proven SLA®[1] surface one step further through its improved surface chemistry. With its hydrophilic and chemically active properties, SLActive promotes faster osseointegration and leads to earlier secondary stability than SLA. By achieving secondary stability sooner, SLActive "shifts" the stability dip (Fig. 2).

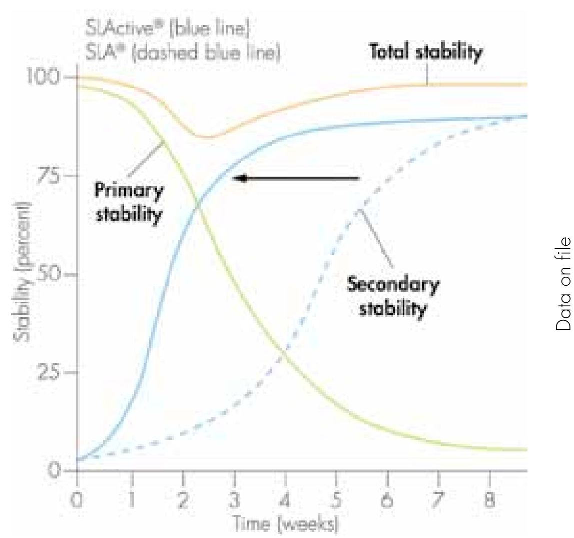


Fig. 2: *The faster osseointegration with SLActive leads to an earlier implant stability between week 2 and 4.*

The benefits for patient and clinician:

By achieving implant stability earlier than SLA in the critical treatment period of 2 to 4 weeks after implant placement, SLActive offers increased treatment predictability with shorter treatment times in all indications.

[1] As shown in animal studies

Study overview

PRECLINICAL STUDIES			
#	**TOPIC**	**AUTHORS**	**REFERENCE**
1	Comparison of bone apposition at the surface of SLA® and SLActive® implants	Buser D, et al.	J Dent Res. 2004 Jul;83(7):529-33.
2	Effects of molecular and cellular interactions on various treated titanium surfaces	Scheideler L, et al.	J Dent Res. 84(Spec Iss A):870,2005 (www.dentalresearch.org).
3	Comparison of early cellular activity at hydrophilic and hydrophobic surface	Zhao G, et al.	J Biomed Mater Res A. 2005 Jul 1;74(1):49-58.
4	Evaluation of surface free energy (SFE) and hydrophilicity of different titanium surfaces	Rupp F, et al.	J Biomed Mater Res A. 2006 Feb;76(2):323-34.
5	Comparison of biomechanical properties of SLA and SLActive implants	Ferguson SJ, et al.	J Biomed Mater Res A. 2006 Aug;78(2):291-7.
6	Effects of surface hydrophilicity and microtopography on early stages of soft and hard tissue integration	Schwarz F, et al.	J Periodontol. 2007 Nov;78(11):2171-84.
7	Evaluation of Initial and early subepithelial connective tissue attachment to SLA and SLActive implants	Schwarz F, et al.	Clin Oral Investig. 2007 Sep;11(3):245-55. Epub 2007 Mar 15.
8	Assessment of initial and early osseous integration at SLA and SLActive implants	Schwarz F, et al.	Clin Oral Implants Res. 2007 Aug;18(4):481-8. Epub 2007 Apr 30.
9	Proliferation of MG63 and primary cells on various treated titanium surfaces	Rausch-fan X, et al.	Dent Mater. 2008 Jan;24(1):102-10. Epub 2007 Apr 27.
10	An experimental comparison of two different clinically used implant designs and surfaces	Gottlow J, et al.	Clin Implant Dent Relat Res. 2012 May;14 Suppl 1:e204-12. doi: 10.1111/j.1708-8208.2012.00439.x. Epub 2012 Apr 5.
11	Comparison of bone apposition around SLA and SLActive implants	Bornstein MM, et al.	Clin Oral Implants Res. 2008 Mar;19(3):233-41. Epub 2008 Jan 3.
12	Bone regeneration with SLActive in dehiscence-type defects	Schwarz F, et al.	Study 1: J Clin Periodontol. 2007 Jan;34(1):78-86. Epub 2006 Nov 24. Study 2: J Clin Periodontol. 2008 Jan;35(1):64-75. Epub 2007 Nov 21.
13	Comparison of bone apposition around SLA and SLActive implants at sites with coronal circumferential defects	Lai HC, et al.	Clin Oral Implants Res. 2009 Mar;20(3):247-53.
14	Influence of titanium implant surface characteristics on bone regeneration in dehiscence-type defects	Schwarz F, et al.	J Clin Periodontol. 2010 May;37(5):466-73.
CLINICAL STUDIES			
#	**TOPIC**	**AUTHORS**	**REFERENCE**
15	Comparison of SLA and SLActive implant stability	Oates TW, et al.	Int J Oral Maxillofac Implants. 2007 Sep-Oct;22(5):755-60.
16	Immediate and early loading of chemically modified implants in posterior jaws: 3-year results from a prospective randomized multicenter study	Nicolau P, et al.	Clin Implant Dent Relat Res. 2011 Dec 15. doi: 10.1111/j.1708-8208.2011.00418.x. [Epub ahead of print].
17	3 weeks loading of SLActive implants in the maxillary molar region	Roccuzzo M and Wilson TG Jr.	Int J Oral Maxillofac Implants. 2009 Jan-Feb;24(1):65-72.
18	Early loading of nonsubmerged SLActive implants	Bornstein MM, et al.	Clin Implant Dent Relat Res. 2009 Dec;11(4):338-47. Epub 2009 Apr 23.
19	Early loading at 21 days of non-submerged SLActive implants	Bornstein MM, et al.	J Periodontol. 2010 Jun;81(6):809-18.
20	Early loading after 21 days of healing of nonsubmerged SLActive implants	Morton D, et al.	Clin Implant Dent Relat Res. 2010 Mar;12(1):9-17. Epub 2009 Sep 9.
21	Early osseointegration to hydrophilic and hydrophobic implant surfaces in humans	Lang NP, et al.	Clin Oral Implants Res. 2011 Apr;22(4):349-56. doi: 10.1111/j.1600.0501.2011.02172.x.
22	A multicenter prospective 'non-interventional' study about Straumann® SLActive implants	Luongo G and Oteri G.	J Oral Implantol. 2010;36(4):305-14.

1 Enhanced bone apposition to a chemically modified SLA® titanium surface

Buser D, Broggini N, Wieland M, Schenk RK, Denzer AJ, Cochran DL, Hoffmann B, Lussi A, Steinemann SG.
J Dent Res. 2004 Jul;83(7):529-33.

Abstract: The degree of bone apposition at the implant surface was compared between SLA® and SLActive® implants in miniature pigs. After 2 and 4 weeks, there was a significantly greater percentage (up to 60%) of bone-to-implant contact with SLActive.

Conclusions

- Bone apposition is significantly enhanced in the early osseointegration stages with SLActive
- 60% more bone (BIC) after 2 weeks with SLActive compared to SLA
- Earlier formation of more mature bone
- SLActive further reduces the healing period following implantation

2 Storage conditions of titanium implants influence molecular and cellular interactions

Scheideler L, Rupp F, Wieland M, Geis-Gerstorfer J.
J Dent Res. 84(Spec Iss A):870,2005 (www.dentalresearch.org).

Abstract: The effects of protein and cellular interactions were compared on a variety of treated titanium surfaces, including SLA® and SLActive®. The chemically modified surface of SLActive was found to increase osteoblast proliferation and significantly increase protein adsorption in the in vitro environment.

Conclusions

- SLActive surface enhances osteoblast-surface and cell-surface interactions compared to SLA
- SLActive shows a significantly higher fibronectin adsorption (162%) compared to SLA and other surface types
- Effects may be due to increased hydrophilicity and surface free energy, and may improve clinical healing *in vivo*

3 High surface energy enhances cell response to titanium substrate microstructure

Zhao G, Schwartz Z, Wieland M, Rupp F, Geis-Gerstorfer J, Cochran DL, Boyan BD.
J Biomed Mater Res A. 2005 Jul 1;74(1):49-58.

Abstract: The early cellular activity at the hydrophilic SLActive® surface was evaluated and compared with the hydrophobic SLA®. The osteoblast differentiation was enhanced with SLActive, and production of osteogenic factors, such as osteocalcin, alkaline phosphatase, PGE_2 and TGF-β1, was significantly increased in vitro.

Conclusions

- Osteocalcin production with SLActive is significantly increased
- Osteoblast activity was clearly enhanced as a result of the chemically activated SLActive surface
- A significantly enhanced production of local growth factors up to 10-fold is present
- Osteogenic properties are optimized

Enhancing surface free energy and hydrophilicity through chemical modification of microstructured titanium implant surfaces

4

Rupp F, Scheideler L, Olshanska N, de Wild M, Wieland M, Geis-Gerstorfer J.
J Biomed Mater Res A. 2006 Feb;76(2):323-34.

Abstract: The hydrophilicity and surface free energy (SFE) of different titanium surface preparations, including SLActive®, were evaluated. Both SFE and hydrophilicity were found to be increased with the SLActive surface, and reduced atmospheric contamination was observed.

Conclusions

- SLActive is highly hydrophilic (water contact angle of 0° versus 139.9° for SLA)
- The SLActive surface shows reduced atmospheric contamination
- Surface free energy is much higher with SLActive

Biomechanical evaluation of the interfacial strength of a chemically modified sandblasted and acid-etched titanium surface

5

Ferguson SJ, Broggini N, Wieland M, de Wild M, Rupp F, Geis-Gerstorfer J, Cochran DL, Buser D.
J Biomed Mater Res A. 2006 Aug;78(2):291-7.

Abstract: The biomechanical properties of SLActive® and SLA® implants were compared in a split-mouth study in adult miniature pigs. After 2, 4 and 8 weeks of healing, removal torque and interfacial stiffness values were significantly higher for SLActive.

Conclusions

- Bone apposition is enhanced with the SLActive surface
- Interfacial mechanical stiffness and strength is significantly greater with SLActive
- SLActive gives higher implant stability during the critical early weeks of osseointegration

Effects of surface hydrophilicity and microtopography on early stages of soft and hard tissue integration at non-submerged titanium implants: an immunohistochemical study in dogs

6

Schwarz F, Ferrari D, Herten M, Mihatovic I, Wieland M, Sager M, Becker J.
J Periodontol. 2007 Nov;78(11):2171-84.

Abstract: SLA® or SLActive® implants with different transmucosal surface preparations were placed in dogs and evaluated by histomorphometry and immunohistochemistry for up to 28 days. Surface hydrophilicity was found to have a greater effect on soft and hard tissue integration.

Conclusions

- Soft and hard tissue integration was influenced mainly by surface hydrophilicity rather than microtopography

7

Histological and immunohistochemical analysis of initial and early subepithelial connective tissue attachment at chemically modified and conventional SLA® titanium implants. A pilot study in dogs

Schwarz F, Herten M, Sager M, Wieland M, Dard M, Becker J.
Clin Oral Investig. 2007 Sep;11(3):245-55. Epub 2007 Mar 15.

Abstract: Subepithelial connective tissue attachment to SLA and SLActive implants was evaluated in dogs for up to 14 days. The results indicated that the SLActive surface may have the potential to enhance attachment of the connective tissue, with well organized collagen and blood vessel formation.

Conclusions

- The SLActive surface may have the potential to promote subepithelial connective tissue attachment at the transmucosal part of implants
- The results underscore the biological impact of the SLActive surface

8

Histological and immunohistochemical analysis of initial and early osseous integration at chemically modified and conventional SLA® titanium implants: preliminary results of a pilot study in dogs

Schwarz F, Herten M, Sager M, Wieland M, Dard M, Becker J.
Clin Oral Implants Res. 2007 Aug;18(4):481-8. Epub 2007 Apr 30.

Abstract: Early tissue reactions around SLA and SLActive® implants were assessed. During a period of 14 days, faster and more structured bone formation was observed around the SLActive implants, with greater vascularization and increased osteocalcin activity.

Conclusions

- Significantly increased proliferation of vascular structures with SLActive throughout days 1–14
- Significantly increased activity of osteocalcin at the bone-to-implant interface, and enhanced bone formation processes with SLActive
- Quantitative and qualitative analysis showed significant differences in bone formation

9

Differentiation and cytokine synthesis of human alveolar osteoblasts compared to osteoblast-like cells (MG63) in response to titanium surfaces

Rausch-fan X, Qu Z, Wieland M, Matejka M, Schedle A.
Dent Mater. 2008 Jan;24(1):102-10. Epub 2007 Apr 27.

Abstract: Early cellular processes were assessed on various treated titanium surfaces. Initial results show substantially increased production of osteocalcin and local growth and vascularization factors in vitro with SLActive®.

Conclusions

- A significantly enhanced early osteoblast activity can be seen as a result of the chemically activated SLActive surface
- There is a substantially increased production of osteocalcin and osteoprotegerin with SLActive
- There was substantially increased production of local growth and vascularization factors with SLActive

An experimental comparison of two different clinically used implant designs and surfaces

10

Gottlow J, Barkamo S, Sennerby L.
Clin Implant Dent Relat Res. 2012 May;14 Suppl 1:e204-12. doi: 10.1111/j.1708-8208.2012.00439.x. Epub 2012 Apr 5.

Abstract: The bone tissue responses and implant stability of Straumann SLActive® implants and Nobel TiUnite® implants were compared at 10 days, 3 weeks, and 6 weeks of healing. Results showed that no single factor, such as design or surface can be isolated and compared independently. Results support the impact of the SLActive implant surface in the early stages of osseointegration.

Conclusions

- SLActive implants showed more BIC after 10 days, while TiUnite implants showed more BIC at 6 weeks of healing
- SLActive implants showed significantly higher shear strength after 3 and 6 weeks and higher removal torque values after 3 weeks compared to TiUnite
- Results suggest that surface roughness and hydrophilic properties influence the osseointegration process

Bone apposition around two different sandblasted and acid-etched titanium implant surfaces: A histomorphometric study in canine mandibles

11

Bornstein MM, Valderrama P, Jones AA, Wilson TG, Seibl R, Cochran DL.
Clin Oral Implants Res. 2008 Mar;19(3):233-41. Epub 2008 Jan 3.

Abstract: The degree of bone apposition around SLActive® and SLA® implants was compared in foxhounds. Results suggest greater and more mature bone growth 2 weeks after implant placement.

Conclusions

- Pronounced increase of bone formation around SLActive compared to SLA in the early stage of implant integration in vivo
- Significant increase of bone formation in the period between 2 and 4 weeks of healing both for SLA and SLActive implants

Bone regeneration with SLActive® in dehiscence-type defects in dogs: histological, histomorphometric and immunohistological analyses

12

Study 1:
Bone regeneration in dehiscence-type defects at chemically modified (SLActive®) and conventional SLA® titanium implants: a pilot study in dogs.
Schwarz F, Herten M, Sager M, Wieland M, Dard M, Becker J.
J Clin Periodontol. 2007 Jan;34(1):78-86. Epub 2006 Nov 24.

Study 2:
Bone regeneration in dehiscence-type defects at non-submerged and submerged chemically modified (SLActive®) and conventional SLA® titanium implants: an immunohistochemical study in dogs.
Schwarz F, Sager M, Ferrari D, Herten M, Wieland M, Becker J.
J Clin Periodontol. 2008 Jan;35(1):64-75. Epub 2007 Nov 21.

Abstract: The aims of the present studies were to evaluate bone regeneration in dehiscence-type defects at titanium implants with SLActive and SLA surfaces. The results indicated that SLActive promotes bone regeneration in dehiscence-type defects.

Conclusions

- SLActive promotes bone regeneration in dehiscence-type defects
- SLActive promotes the production of significantly greater and more mature bone than SLA
- Significant increases in new bone height, bone fill and bone-to-implant contact are seen with SLActive
- Complete bone fill can be obtained with SLActive

13

Bone apposition around two different sandblasted, large-grit and acid-etched implant surfaces at sites with coronal circumferential defects: an experimental study in dogs.

Lai HC, Zhuang LF, Zhang ZY, Wieland M, Liu X.
Clin Oral Implants Res. 2009 Mar;20(3):247-53.

Abstract: SLA® and SLActive® implants were placed in the premolar and molar positions in the mandibles of dogs, with or without a gap around the coronal part of the implant. Greater early bone apposition was observed with the SLActive surface, and the results indicated that small gaps may not require a regenerative procedure.

Conclusions

- Greater bone apposition was observed in the early stages of healing for the SLActive surface compared to the SLA surface
- The surface characteristics of the SLActive surface may therefore enhance bone apposition in coronal circumferential defects at non-submerged implants
- A defect gap size < 1.0 mm may not require a regenerative procedure

14

Influence of titanium implant surface characteristics on bone regeneration in dehiscence-type defects: an experimental study in dogs

Schwarz F, Sager M, Kadelka I, Ferrari D, Becker J.
J Clin Periodontol. 2010 May;37(5):466-73.

Abstract: Implants with either an SLActive® or a NanoTite® surface were placed in dehiscence-type defects in dogs and underwent submerged healing for 2 or 8 weeks. Histomorphometric analysis showed greater new bone height and bone-to-implant contact for SLActive, suggesting (within the limits of this study) SLActive may have a higher potential to support osseointegration in dehiscence-type defects.

Conclusions

- New bone height and bone-to-implant contact were significantly higher for SLActive implants
- SLActive implants may have a higher potential to support osseointegration in dehiscence-type defects than NanoTite implants

Enhanced implant stability with a chemically modified SLA® surface: a randomized pilot study 15

Oates TW, Valderrama P, Bischof M, Nedir R, Jones A, Simpson J, Toutenburg H, Cochran DL.
Int J Oral Maxillofac Implants. 2007 Sep-Oct;22(5):755-60.

Abstract: Implant stability, measured by resonance frequency analysis, was compared for SLA and SLActive® implants over the first 6 weeks following implant placement in humans. After an initial decrease in stability for both groups, stability increased with SLActive implants at a much earlier stage than with SLA implants (2 weeks versus 4 weeks).

Conclusions

- Significant improvement in the stability pattern with SLActive
- Increased stability at an earlier stage with SLActive (break point after 2 weeks with SLActive versus 4 weeks with SLA)
- Results suggest faster healing and osseointegration with SLActive
- SLActive has the potential for reduced risks and more predictability in early/immediate loading procedures

Immediate and early loading of chemically modified implants in posterior jaws: 3-year results from a prospective randomized multicenter study 16

Nicolau P, Korostoff J, Ganeles J, Jackowski J, Krafft T, Neves M, Divi J, Rasse M, Guerra F, Fischer K.
Clin Implant Dent Relat Res. 2011 Dec 15. doi: 10.1111/j.1708-8208.2011.00418.x. [Epub ahead of print].

Abstract: SLActive implants were placed in the mandible and/or maxilla of 266 patients and restored immediately or after 28-34 days. Survival rates after 36 months were high and were not significantly different between the two groups. Similarly, the change in mean bone level was not significantly different between the groups, after adjusting for implantation depth. Several cases of bone gain were observed.

Conclusions

- Immediate and early loading with Straumann SLActive implants yields excellent survival rates (97.4% and 96.7% respectively after 3 years)
- Immediate loading is as successful as early loading with Straumann SLActive implants
- Successful implant treatment is possible with Straumann SLActive even in poor quality bone
- No implant failures were evident in Type IV bone

A prospective study of 3 weeks' loading of chemically modified titanium implants in the maxillary molar region: 1-year results 17

Roccuzzo M, Wilson TG Jr.
Int J Oral Maxillofac Implants. 2009 Jan-Feb;24(1):65-72.

Abstract: SLActive® implants were placed in the posterior maxilla, which tends to have lower bone density, and loaded after 3 weeks. Preliminary results suggest no complications and no early implant failures in this challenging indication.

Conclusions

- Successful functional loading is possible in the maxillary molar region after 3 weeks with SLActive implants
- Implant survival was 100 % after 12 months in low density bone
- The procedure represents an important step towards faster healing and increased treatment predictability

18

Early loading of nonsubmerged titanium implants with a chemically modified sand-blasted and acid-etched surface: 6-month results of a prospective case series study in the posterior mandible focusing on peri-implant crestal bone changes and implant stability quotient (ISQ) values

Bornstein MM, Hart CN, Halbritter SA, Morton D, Buser D.
Clin Implant Dent Relat Res. 2009 Dec;11(4):338-47. Epub 2009 Apr 23.

Abstract: Forty patients received 56 SLActive® implants, which were functionally loaded after 3 weeks. Implant stability (ISQ) was measured at various time points for up to 26 weeks and showed a steady increase from implant placement to week 26.

Conclusion

- Early loading with SLActive implants 3 weeks after placement in the posterior mandible has a low risk for early failures
- Definitive functional restoration after 3 weeks is possible

19

Early loading at 21 days of non-submerged titanium implants with a chemically modified sandblasted and acid-etched surface: 3-year results of a prospective study in the posterior mandible

Bornstein MM, Wittneben JG, Brägger U, Buser D.
J Periodontol. 2010 Jun;81(6):809-18.

Abstract: SLActive® implants were placed in patients and functionally loaded after 21 days; clinical and radiographic parameters were evaluated for up to 36 months. No implants were lost and clinical attachment levels and probing depths were improved versus historical SLA® controls.

Conclusion

- Early loaded SLActive implants can achieve and maintain successful tissue integration over 3 years
- The procedure offers rehabilitation with a definitive restoration after 3 weeks, increasing cost-effectiveness for the patient
- Loading after 3 weeks can be recommended in defined clinical situations for standard sites without bone defects

20

Early loading after 21 days of healing of nonsubmerged titanium implants with a chemically modified sandblasted and acid-etched surface: two-year results of a prospective two-center study

Morton D, Bornstein MM, Wittneben JG, Martin WC, Ruskin JD, Hart CN, Buser D.
Clin Implant Dent Relat Res. 2010 Mar;12(1):9-17. Epub 2009 Sep 9.

Abstract: Results from early loading of SLActive® implants after 3 weeks suggest that successful integration can be achieved without increasing the risk of implant loss.

Conclusion

- Tissue level implants with the SLActive surface can predictably achieve successful tissue integration when loaded with full occlusion after 21 days.
- This study indicates that early loading of SLActive implants in the posterior mandible has a reasonably low risk for early failures (2.2%).
- The concept of early loading offers a straightforward treatment with definitive restoration after a 3-week healing period and accordingly offers good cost-effectiveness.

Early osseointegration to hydrophilic and hydrophobic implant surfaces in humans

21

Lang NP, Salvi GE, Huynh-Ba G, Ivanovski S, Donos N, Bosshardt DD.
Clin Oral Implants Res. 2011 Apr;22(4):349-56. doi: 10.1111/j.1600.0501.2011.02172.x.

Abstract: The rate and degree of osseointegration at the SLA® and SLActive® implant surfaces during the early phases of healing were compared in a human model via histological analysis. Results revealed similar healing patterns for both the SLA and SLActive surfaces, with significantly more bone-to-implant contact (BIC) at SLActive compared to SLA at 28 days.

Conclusions
- Similar healing patterns were observed for both SLA® and SLActive® implants
- Osseointegration (BIC) was greater after 14 days and significantly greater after 28 days for SLActive®
- The rate of osseointegration was substantially slower (approximately double the healing time) in humans than that observed in animal studies
- This is the first study to demonstrate histologically the osseointegration process with SLActive® in humans

A noninterventional study documenting use and success of implants with a new chemically modified titanium surface in daily dental practice

22

Luongo G, Oteri G.
J Oral Implantol. 2010;36(4):305-14.

Abstract: A multicenter non-interventional study was conducted, in which 276 SLActive implants were placed and documented in 218 patients according to situations where implants would normally be placed. After 1 year the survival and success rate was 98.2%, similar to that observed in strictly controlled clinical trials.

Conclusions
- The 1-year cumulative survival and success rate was 98.2%
- All failed implants were associated with a simultaneous sinus floor augmentation procedure
- The success rate of SLActive implants in daily practice is similar to that observed in formal clinical trials with strictly controlled patient populations

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