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Title: **Torque factor** in implant dentistry

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Literature

1. Abrahamsson I, Berglundh T, Linder E, Lang NP, Lindhe J. Early bone formation adjacent to rough and turned endosseous implant surfaces. An experimental study in the dog. *Clin Oral Implants Res.* 2004 Aug;15(4):381–92. doi: 10.1111/j.1600-0501.2004.01082.x.
2. Abrahamsson I, Linder E, Lang NP. Implant stability in relation to osseointegration: an experimental study in the Labrador dog. *Clin Oral Implants Res.* 2009 Mar;20(3):313–8. doi: 10.1111/j.1600-0501.2008.01646.x.
3. Abrahamsson I, Carcuac O, Berglundh T. Influence of implant geometry and osteotomy design on early bone healing: a pre-clinical in vivo study. *Clin Oral Implants Res.* 2021 Oct;32(10):1190–9. doi: 10.1111/clr.13816.
4. Adell R, Lekholm U, Rockler B, Brånemark PI. A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. *Int J Oral Surg.* 1981 Dec;10(6):387–16. doi: 10.1016/s0300-9785(81)80077-4.
5. Albrektsson T, Sennerby L. State of the art in oral implants. *J Clin Periodontol.* 1991 Jul;18(6):474–81. doi: 10.1111/j.1600-051x.1991.tb02319.x.
6. Albrektsson T, Brånemark PI, Hansson HA, Lindström J. Osseointegrated titanium implants. Requirements for ensuring a long-lasting, direct bone-to-implant anchorage in man. *Acta Orthop Scand.* 1981;52(2):155–70. doi: 10.3109/17453678108991776.
7. Albrektsson T, Eriksson AR, Friberg B, Lekholm U, Lindahl L, Nevins M, Oikarinen V, Roos J, Sennerby L, Astrand P. Histologic investigations on 33 retrieved Nobelpharma implants. *Clin Mater.* 1993;12(1):1–9. doi: 10.1016/0267-6605(93)90021-x.
8. Albrektsson T, Zarb G, Worthington P, Eriksson AR. The long-term efficacy of currently used dental implants: a review and proposed criteria of success. *Int J Oral Maxillofac Implants.* 1986 Summer;1(1):11–25.
9. Barone A, Alfonsi F, Derchi G, Tonelli P, Toti P, Marchionni S, Covani U. The effect of insertion torque on the clinical outcome of single implants: a randomized clinical trial. *Clin Implant Dent Relat Res.* 2016 Jun;18(3):588–600. doi: 10.1111/cid.12337.
10. Berglundh T, Abrahamsson I, Lang NP, Lindhe J. De novo alveolar bone formation adjacent to endosseous implants. *Clin Oral Implants Res.* 2003 Jun;14(3):251–62. doi: 10.1034/j.1600-0501.2003.00972.x.
11. Smith DE, Zarb GA. Criteria for success of osseointegrated endosseous implants. *J Prosthet Dent.* 1989 Nov;62(5):567–72. doi: 10.1016/0022-3913(89)90081-4.
12. Bonfante EA, Granato R, Marin C, Suzuki M, Oliveira SR, Giro G, Coelho PG. Early bone healing and biomechanical fixation of dual acid-etched and as-machined implants with healing chambers: an experimental study in dogs. *Int J Oral Maxillofac Implants.* 2011 Jan–Feb;26(1):75–82.

13. Brånemark PI, Adell R, Breine U, Hansson BO, Lindström J, Ohlsson A. Intra-osseous anchorage of dental prostheses. I. Experimental studies. *Scand J Plast Reconstr Surg.* 1969;3(2):81–100. doi: 10.3109/02844316909036699.
14. Brånemark PI. Introduction to osseointegration. In: Brånemark PI, Zarb G, Albrektsson T, editors. *Tissue-integrated prostheses: osseointegration in clinical dentistry.* Chicago: Quintessence; 1985. p. 11–76.
15. Buser D, Broggini N, Wieland M, Schenk RK, Denzer AJ, Cochran DL, Hoffmann B, Lussi A, Steinemann SG. Enhanced bone apposition to a chemically modified SLA titanium surface. *J Dent Res.* 2004 Jul;83(7):529–33. doi: 10.1177/154405910408300704.
16. Campos FE, Gomes JB, Marin C, Teixeira HS, Suzuki M, Witek L, Zanetta-Barbosa D, Coelho PG. Effect of drilling dimension on implant placement torque and early osseointegration stages: an experimental study in dogs. *J Oral Maxillofac Surg.* 2012 Jan;70(1):e43–50. doi: 10.1016/j.joms.2011.08.006.
17. Cha JY, Pereira MD, Smith AA, Houschyar KS, Yin X, Mouraret S, Brunski JB, Helms JA. Multiscale analyses of the bone-implant interface. *J Dent Res.* 2015 Mar;94(3):482–90. doi: 10.1177/0022034514566029.
18. Chamay A, Tschantz P. Mechanical influences in bone remodeling. Experimental research on Wolff's law. *J Biomech.* 1972 Mar;5(2):173–80. doi: 10.1016/0021-9290(72)90053-x.
19. Chen H, Liu N, Xu X, Qu X, Lu E. Smoking, radiotherapy, diabetes and osteoporosis as risk factors for dental implant failure: a meta-analysis. *PLoS One.* 2013 Aug 5;8(8):e71955. doi: 10.1371/journal.pone.0071955.
20. Chess JT. Technique for placement of root form implants of the finned or serrated type. *J Am Dent Assoc.* 1990 Sep;121(3):414–7. doi: 10.14219/jada.archive.1990.0150.
21. Cochran DL, Schenk RK, Lussi A, Higginbottom FL, Buser D. Bone response to unloaded and loaded titanium implants with a sandblasted and acid-etched surface: a histometric study in the canine mandible. *J Biomed Mater Res.* 1998 Apr;40(1):1–11. doi: 10.1002/(sici)1097-4636(199804)40:1<1::aid-jbm1>3.0.co;2-q.
22. Coelho PG, Bonfante EA, Marin C, Granato R, Giro G, Suzuki M. A human retrieval study of plasma-sprayed hydroxyapatite-coated plateau root form implants after 2 months to 13 years in function. *J Long Term Eff Med Implants.* 2010;20(4):335–42. doi: 10.1615/jlongtermeffmedimplants.v20.i4.80.
23. Coelho PG, Granato R, Marin C, Teixeira HS, Suzuki M, Valverde GB, Janal MN, Lilin T, Bonfante EA. The effect of different implant macrogeometries and surface treatment in early biomechanical fixation: an experimental study in dogs. *J Mech Behav Biomed Mater.* 2011 Nov;4(8):1974–81. doi: 10.1016/j.jmbbm.2011.06.016.
24. Coelho PG, Jimbo R. Osseointegration of metallic devices: current trends based on implant hardware design. *Arch Biochem Biophys.* 2014 Nov 1;561:99–108. doi: 10.1016/j.abb.2014.06.033.
25. Coelho PG, Marin C, Granato R, Suzuki M. Histomorphologic analysis of 30 plateau root form implants retrieved after 8 to 13 years in function. A human retrieval study. *J Biomed Mater Res B Appl Biomater.* 2009 Nov;91(2):975–9. doi: 10.1002/jbm.b.31455.
26. Coelho PG, Suzuki M, Guimaraes MV, Marin C, Granato R, Gil JN, Miller RJ. Early bone healing around different implant bulk designs and surgical techniques: a study in dogs. *Clin Implant Dent Relat Res.* 2010 Sep;12(3):202–8. doi: 10.1111/j.1708-8208.2009.00153.x.
27. Coelho PG, Teixeira HS, Marin C, Witek L, Tovar N, Janal MN, Jimbo R. The in vivo effect of P-15 coating on early osseointegration. *J Biomed Mater Res B Appl Biomater.* 2014 Apr;102(3):430–40. doi: 10.1002/jbm.b.33020.

28. Coelho PG, Suzuki M. Evaluation of an IBAF thin-film process as an alternative method for surface incorporation of bioceramics on dental implants: a study in dogs. *J Appl Oral Sci.* 2005 Mar;13(1):87–92. doi: 10.1590/s1678-77572005000100018.
29. Cohen O, Ormianer Z, Tal H, Rothamel D, Weinreb M, Moses O. Differences in crestal bone-to-implant contact following an under-drilling compared to an over-drilling protocol. A study in the rabbit tibia. *Clin Oral Investig.* 2016 Dec;20(9):2475–80. doi: 10.1007/s00784-016-1765-8.
30. Dard M, Kuehne S, Obrecht M, Grandin M, Helfenstein J, Pippenger BE. Integrative performance analysis of a novel bone level tapered implant. *Adv Dent Res.* 2016 Mar;28(1):28–33. doi: 10.1177/0022034515624443.
31. Davies JE. Understanding peri-implant endosseous healing. *J Dent Educ.* 2003 Aug;67(8):932–49.
32. De Santis D, Cucchi A, Rigoni G, Longhi C, Nocini PF. Relationship between primary stability and crestal bone loss of implants placed with high insertion torque: a 3-year prospective study. *Int J Oral Maxillofac Implants.* 2016 Sep–Oct;31(5):1126–34. doi: 10.11607/jomi.4594.
33. Donath K, Breuner G. A method for the study of undecalcified bones and teeth with attached soft tissues. The Säge-Schliff (sawing and grinding) technique. *J Oral Pathol.* 1982 Aug;11(4):318–26. doi: 10.1111/j.1600-0714.1982.tb00172.x.
34. Driskell TD, O'Hara MJ, Greene GW Jr (Battelle Columbus Laboratories, Columbus, OH). Surgical tooth implants, combat and field. Frederick, MD: Army Medical Research and Development Command (US): 1971. number p. Report No.: 1. Contract No.: DADA17-69-C-9181.
35. Elias CN, Rocha FA, Nascimento AL, Coelho PG. Influence of implant shape, surface morphology, surgical technique and bone quality on the primary stability of dental implants. *J Mech Behav Biomed Mater.* 2012 Dec;16:169–80. doi: 10.1016/j.jmbbm.2012.10.010.
36. Ellingsen JE, Johansson CB, Wennerberg A, Holmén A. Improved retention and bone-to-implant contact with fluoride-modified titanium implants. *Int J Oral Maxillofac Implants.* 2004 Sep–Oct;19(5):659–66.
37. Eom TG, Kim HW, Jeon GR, Yun MJ, Huh JB, Jeong CM. Effects of different implant osteotomy preparation sizes on implant stability and bone response in the minipig mandible. *Int J Oral Maxillofac Implants.* 2016 Sep–Oct;31(5):997–1006. doi: 10.11607/jomi.4165.
38. Fiorellini JP, Martuscelli G, Weber HP. Longitudinal studies of implant systems. *Periodontol* 2000. 1998 Jun;17:125–31. doi: 10.1111/j.1600-0757.1998.tb00130.x.
39. Gehrke SA, Pérez-Díaz L, Mazón P, De Aza PN. Biomechanical effects of a new macrogeometry design of dental implants: an in vitro experimental analysis. *J Funct Biomater.* 2019 Oct 25;10(4):47. doi: 10.3390/jfb10040047.
40. Gomes JB, Campos FE, Marin C, Teixeira HS, Bonfante EA, Suzuki M, Witek L, Zanetta-Barbosa D, Coelho PG. Implant biomechanical stability variation at early implantation times in vivo: an experimental study in dogs. *Int J Oral Maxillofac Implants.* 2013 May–Jun;28(3):e128–34. doi: 10.11607/jomi.2885.
41. Gotfredsen K, Nimb L, Hjørting-Hansen E, Jensen JS, Holmén A. Histomorphometric and removal torque analysis for TiO₂-blasted titanium implants. An experimental study on dogs. *Clin Oral Implants Res.* 1992 Jun;3(2):77–84. doi: 10.1034/j.1600-0501.1992.030205.x.
42. Gottlow J, Barkarmo S, Sennerby L. An experimental comparison of two different clinically used implant designs and surfaces. *Clin Implant Dent Relat Res.* 2012 May;14 Suppl 1:e204–12. doi: 10.1111/j.1708-8208.2012.00439.x.

43. Halldin A, Jimbo R, Johansson CB, Wennerberg A, Jacobsson M, Albrektsson T, Hansson S. The effect of static bone strain on implant stability and bone remodeling. *Bone*. 2011 Oct;49(4):783–9. doi: 10.1016/j.bone.2011.07.003.
44. Huang HL, Chang YY, Lin DJ, Li YF, Chen KT, Hsu JT. Initial stability and bone strain evaluation of the immediately loaded dental implant: an in vitro model study. *Clin Oral Implants Res*. 2011 Jul;22(7):691–8. doi: 10.1111/j.1600-0501.2010.01983.x.
45. Iezzi G, Piattelli A, Mangano C, Shibli JA, Vantaggiato G, Frosecchi M, Di Chiara C, Perrotti V. Peri-implant bone tissues around retrieved human implants after time periods longer than 5 years: a retrospective histologic and histomorphometric evaluation of 8 cases. *Odontology*. 2014 Jan;102(1):116–21. doi: 10.1007/s10266-012-0084-z.
46. Iezzi G, Vantaggiato G, Shibli JA, Fiera E, Falco A, Piattelli A, Perrotti V. Machined and sandblasted human dental implants retrieved after 5 years: a histologic and histomorphometric analysis of three cases. *Quintessence Int*. 2012 Apr;43(4):287–92.
47. Ikar M, Grobecker-Karl T, Karl M, Steiner C. Mechanical stress during implant surgery and its effects on marginal bone: a literature review. *Quintessence Int*. 2020;51(2):142–50. doi: 10.3290/j.qi.a43664.
48. Isidor F. Influence of forces on peri-implant bone. *Clin Oral Implants Res*. 2006 Oct;17 Suppl 2:8–18. doi: 10.1111/j.1600-0501.2006.01360.x.
49. Jiang X, Zhu Y, Liu Z, Tian Z, Zhu S. Association between diabetes and dental implant complications: a systematic review and meta-analysis. *Acta Odontol Scand*. 2021 Jan;79(1):9–18. doi: 10.1080/00016357.2020.1761031.
50. Jimbo R, Sawase T, Shibata Y, Hirata K, Hishikawa Y, Tanaka Y, Bessho K, Ikeda T, Atsuta M. Enhanced osseointegration by the chemotactic activity of plasma fibronectin for cellular fibronectin positive cells. *Biomaterials*. 2007 Aug;28(24):3469–77. doi: 10.1016/j.biomaterials.2007.04.029.
51. Karl M, Irastorza-Landa A. Does implant design affect primary stability in extraction sites? *Quintessence Int*. 2017;48(3):219–24. doi: 10.3290/j.qi.a37690.
52. Kern JS, Kern T, Wolfart S, Heussen N. A systematic review and meta-analysis of removable and fixed implant-supported prostheses in edentulous jaws: post-loading implant loss. *Clin Oral Implants Res*. 2016 Feb;27(2):174–95. doi: 10.1111/clr.12531.
53. Lemons JE. Structure of bone adjacent to different dental implants. In: Davies JE, editor. *Bone engineering*. Toronto: EM Squared; 2000. p. 313–21.
54. Lemons JE. Biomaterials, biomechanics, tissue healing, and immediate-function dental implants. *J Oral Implantol*. 2004;30(5):318–24. doi: 10.1563/0712.1.
55. Leonard G, Coelho P, Polyzois I, Stassen L, Claffey N. A study of the bone healing kinetics of plateau versus screw root design titanium dental implants. *Clin Oral Implants Res*. 2009 Mar;20(3):232–9. doi: 10.1111/j.1600-0501.2008.01640.x.
56. Mangano C, Perrotti V, Raspanti M, Mangano F, Luongo G, Piattelli A, Iezzi G. Human dental implants with a sandblasted, acid-etched surface retrieved after 5 and 10 years: a light and scanning electron microscopy evaluation of two cases. *Int J Oral Maxillofac Implants*. 2013 May–Jun;28(3):917–20. doi: 10.11607/jomi.2666.
57. Marin C, Granato R, Suzuki M, Gil JN, Janal MN, Coelho PG. Histomorphologic and histomorphometric evaluation of various endosseous implant healing chamber configurations at early implantation times: a study in dogs. *Clin Oral Implants Res*. 2010 Jun;21(6):577–83. doi: 10.1111/j.1600-0501.2009.01853.x.
58. Mehl C, Becker ST, Acil Y, Harder S, Wiltfang J, Dabbagh-Afrouz AA, de Buhr W, Kern M. Impact of vertical loading on the implant-bone interface. *Clin Oral Implants Res*. 2013 Aug;24(8):949–56. doi: 10.1111/j.1600-0501.2012.02487.x.

59. Nicolielo LF, Van Dessel J, Jacobs R, Quirino Silveira Soares M, Collaert B. Relationship between trabecular bone architecture and early dental implant failure in the posterior region of the mandible. *Clin Oral Implants Res.* 2020 Feb;31(2):153–61. doi: 10.1111/clr.13551.
60. Norton M. Primary stability versus viable constraint—a need to redefine. *Int J Oral Maxillofac Implants.* 2013 Jan–Feb;28(1):19–21.
61. Norton MR. The influence of low insertion torque on primary stability, implant survival, and maintenance of marginal bone levels: a closed-cohort prospective study. *Int J Oral Maxillofac Implants.* 2017 Jul–Aug;32(4):849–57. doi: 10.11607/jomi.5889.
62. Petrie CS, Williams JL. Comparative evaluation of implant designs: influence of diameter, length, and taper on strains in the alveolar crest. A three-dimensional finite-element analysis. *Clin Oral Implants Res.* 2005 Aug;16(4):486–94. doi: 10.1111/j.1600-0501.2005.01132.x.
63. Piattelli A, Artese L, Penitente E, Iaculli F, Degidi M, Mangano C, Shibli JA, Coelho PG, Perrotti V, Iezzi G. Osteocyte density in the peri-implant bone of implants retrieved after different time periods (4 weeks to 27 years). *J Biomed Mater Res B Appl Biomater.* 2014 Feb;102(2):239–43. doi: 10.1002/jbm.b.33000.
64. Raghavendra S, Wood MC, Taylor TD. Early wound healing around endosseous implants: a review of the literature. *Int J Oral Maxillofac Implants.* 2005 May–Jun;20(3):425–31.
65. Rea M, Lang NP, Ricci S, Mintrone F, González González G, Botticelli D. Healing of implants installed in over- or under-prepared sites—an experimental study in dogs. *Clin Oral Implants Res.* 2015 Apr;26(4):442–6. doi: 10.1111/clr.12390.
66. Roberts WE. Bone tissue interface. *J Dent Educ.* 1988 Dec;52(12):804–9.
67. Roberts WE, Turley PK, Brezniak N, Fielder PJ. Implants: bone physiology and metabolism. *CDA J.* 1987 Oct;15(10):54–61.
68. Rohrer MD, Schubert CC. The cutting-grinding technique for histologic preparation of undecalcified bone and bone-anchored implants. Improvements in instrumentation and procedures. *Oral Surg Oral Med Oral Pathol.* 1992 Jul;74(1):73–8. doi: 10.1016/0030-4220(92)90218-f.
69. Sennerby L. Implant integration and stability. In: Palacci P, Ericsson I, editors. *Esthetic implant dentistry: soft and hard tissue management.* Chicago: Quintessence; 2001. p. 15–31.
70. Stavropoulos A, Cochran D, Obrecht M, Pippenger BE, Dard M. Effect of osteotomy preparation on osseointegration of immediately loaded, tapered dental implants. *Adv Dent Res.* 2016 Mar;28(1):34–41. doi: 10.1177/0022034515624446.
71. Suzuki K, Aoki K, Ohya K. Effects of surface roughness of titanium implants on bone remodeling activity of femur in rabbits. *Bone.* 1997 Dec;21(6):507–14. doi: 10.1016/s8756-3282(97)00204-4.
72. Tian Y, Sadowsky SJ, Brunski JB, Yuan X, Helms JA. Effects of masticatory loading on bone remodeling around teeth versus implants: insights from a preclinical model. *Clin Oral Implants Res.* 2022 Mar;33(3):342–52. doi: 10.1111/clr.13894.
73. Toia M, Stoccherio M, Cecchinato F, Corrà E, Jimbo R, Cecchinato D. Clinical considerations of adapted drilling protocol by bone quality perception. *Int J Oral Maxillofac Implants.* 2017 Nov–Dec;32(6):1288–95. doi: 10.11607/jomi.5881.
74. Lemons JE. Biocompatibility of implant materials. In: Lawrence P. Caretto, editor. *Bridging the gap between dental and orthopaedic implants: proceedings of the 3rd Annual Indiana Conference, Indianapolis, Indiana.* Indianapolis, IN: Indiana University School of Dentistry; 2002. p. 79–89.

75. Verborgt O, Gibson GJ, Schaffler MB. Loss of osteocyte integrity in association with microdamage and bone remodeling after fatigue in vivo. *J Bone Miner Res.* 2000 Jan;15(1):60–7. doi: 10.1359/jbmr.2000.15.1.60.
76. Wang L, Wu Y, Perez KC, Hyman S, Brunski JB, Tulu U, Bao C, Salmon B, Helms JA. Effects of condensation on peri-implant bone density and remodeling. *J Dent Res.* 2017 Apr;96(4):413–20. doi: 10.1177/0022034516683932.
77. Wang R, Eppell SJ, Nguyen C, Morris N. Relative contribution of trabecular and cortical bone to primary implant stability: an in vitro model study. *J Oral Implantol.* 2016 Apr;42(2):145–52. doi: 10.1563/aaid-joi-D-14-00322.
78. Wilson TG Jr, Miller RJ, Trushkowsky R, Dard M. Tapered implants in dentistry: revitalizing concepts with technology: a review. *Adv Dent Res.* 2016 Mar;28(1):4–9. doi: 10.1177/0022034516628868.