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Clinical guidelines for using T3® Short Implants

By Francesco Amato, MD, DDS, PhD

Clinical case presentations featuring T3 Short Implants

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Clinical guidelines for using T3® Short Implants

Francesco Amato, MD, DDS, PhD[†], Italy

Although longer implants for many years were thought to be safest, with at least 10mm of implant length considered to be the standard, anatomical limitations often prohibit placement of such implants without undertaking invasive and potentially risky surgical interventions. More recently, good results have been found for the use of short implants to rehabilitate posterior partial edentulism in atrophic maxillary and mandibular bone. To increase the likelihood of long-term success for short implants, this article presents guidelines, including recommendations for platform-switching, treatment staging, splinting, osteotomy preparation, and more. Two maxillary cases illustrating the use of short implants are also presented.

Key words: implants, edentulous, resorption, guidelines, T3 Short Implants

Introduction

The crown-to-root ratio for natural teeth is often viewed as an indicator of tooth prognosis, with a minimum 1:1 ratio recommended and 1:2 seen as the ideal.[1] The increased functional lever arm of an unfavorable crown-to-root ratio is considered a non-axial loading force.[1] When dental implants were first introduced, similar guidelines were adapted. It was assumed that longer implants would prove more advantageous in clinical use than shorter ones, due both to the more favorable crown-to-implant ratio[2] and the greater implant surface area available for osseointegration. Implant dimensions of 4 mm in diameter and at least 10 mm in length became the standard and were considered to be safest,[3] with 10 to 12 mm of residual alveolar bone thought to be the minimum necessary to ensure predictable implant treatment.

In the posterior region, however, that amount of bone height is frequently unavailable,[4-6] and the bone quality may be compromised. The presence of the maxillary sinus or inferior alveolar nerve also may limit the availability of bone in posterior sites[7] (Figs. 1a-b, 2a-b). To overcome such limitations, surgical procedures such as sinus lifts, vertical bone augmentation, guided bone regeneration, alveolar nerve transposition, and placement of tilted implants were developed.[8-10] But these surgical procedures are substantially invasive and pose risks of intra- and post-operative complications, infection, or graft resorption.[11] Bone-augmentation surgeries also increase the length and cost of treatment.

Clinical Guidelines

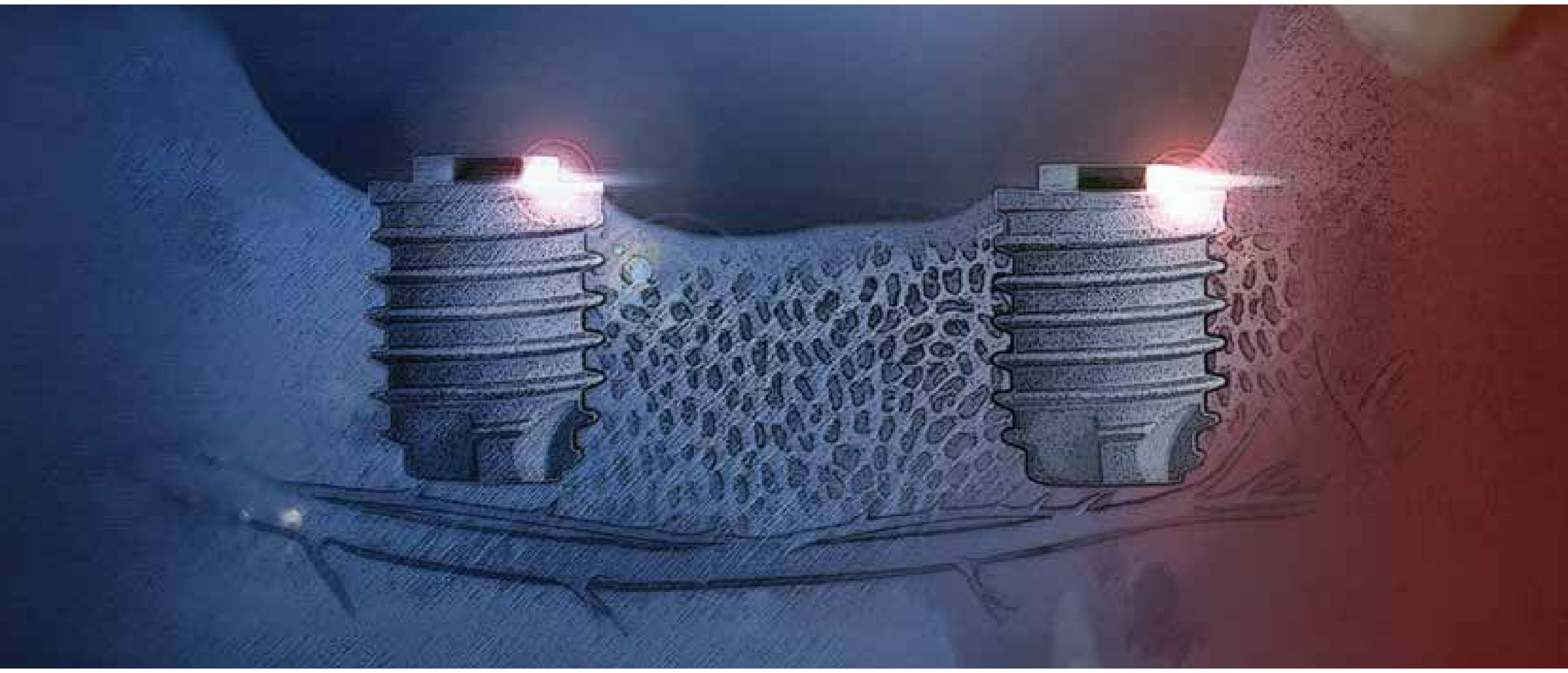

Fig. 1a

Fig. 1b

Figs. 1a, b. Radiograph and Cone Beam CT scan image showing minimal bone height under the maxillary sinus.

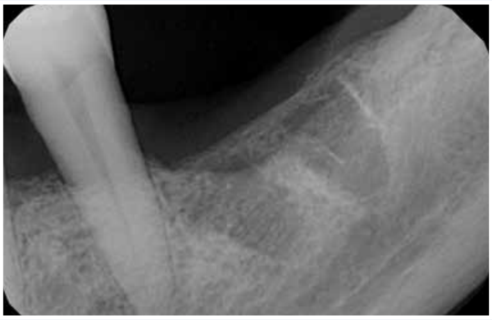

Fig. 2a

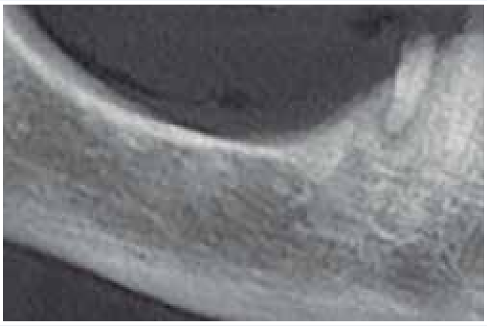

Fig. 2b

Figs. 2a, b. Radiograph and Cone Beam Scan image showing reduced bone height above the inferior alveolar nerve canal.

Fig. 3. T3® Short Implants
5 mmD x 5 mmL and 5 mmD x 6 mmL
6 mmD x 5 mmL and 6 mmD x 6 mmL

An alternative to these surgical procedures is to use short implants.[12,13] The term "short implants" has been controversial, with studies and reviews lacking consensus about its definition.[14] In 1991 8 and 9 mm length implants were introduced and defined as "short." Since then some authors have defined short implants as being less than 7 mm long, while others have extended the definition to include all implants with lengths of up to 10 mm[15] (Fig. 3).

Throughout the 1990s, higher failure rates for shorter implants were reported by a number of investigators.[16-23] However, more recent studies have found better results using short implants to rehabilitate posterior partial edentulism in very atrophic maxillary and mandibular bone. Renouard and Nisand in 2005 reported a 94.6% survival rate after 2 years of loading on short implants placed with high initial stability and good bone-to-implant contact.[24] In a six-year multicenter retrospective study, Misch et al in 2006 found a 98.9% survival rate for 745 7 mm and 9 mm long posterior implants.[25] A 2012 systematic review by Annibali et al that analyzed results of two randomized controlled trials and 14 observational studies and included a total of 6,193 short implants, found a cumulative survival rate of 99.1%, with a low incident of biological and biomechanical complications.[26] Another extensive review of 33 studies of short implants published between 1980 and 2004 found the overall success rate to be 95.2%.[27] While the authors found poor bone quality to be associated with short implant failures, they concluded that the use of implants 4 mm in diameter appeared to minimize failure in such situations.

Several explanations have been offered for the improvement in outcomes for short implants that has become apparent over time. Most importantly, newer surface treatments and wider diameters of short implants in use today increase the bone-to-implant contact exponentially. Whereas early implants had smooth (machined/turned) surfaces, various techniques have since been introduced to alter the implant surface topography, including acid-etching, grit blasting, titanium plasma-spraying, and nanoparticle deposition. These techniques both roughen and increase the implant surface area,[28] and they also have been found to accelerate osseointegration.[29] Evaluating the effect of titanium surface topography on bone integration, Wennerberg and Albrektsson concluded that surface roughness influences bone response at the micrometer level.[30] Many studies have concluded that the advances in surface topography and chemistry have made short implant survival rates comparable to those of standard length implants.[15,31-36]

While some studies have found that neither implant length nor width significantly affects short implant survival rates,[37,38] Anitua et al showed that crestal bone resorption around short implants decreased with increased implant diameter and that using wider implants can reduce the maximum von Mises stress in bone by 20 to 30%.[39]

Other reports of finite element analyses support the hypothesis that the use of shorter implants in appropriate clinical situations yields cumulative survival rates comparable to those reported for longer implants. Lum found that occlusal forces applied to implants were distributed primarily to the crestal bone, regardless of implant length.[40] Lum and Osier also reported that masticatory forces were well tolerated by the crestal bone, but parafunctional forces were not and should be attenuated.[41,42] Holmgren et al[43] and Himmlova et al[44] demonstrated that force application resulted in greatest force concentration at the bone crest. Himmlova et al stated that while implant length had no effect on either the magnitude of peak stress or stress distribution to the supporting bone, implant diameter was more important for improved stress distribution. When Anitua et al in 2010 conducted a finite element analysis of the influence of implant length, diameter, and geometry on implant surface stress distribution, they found stresses to be localized on the first six implant threads, independent of the implant length, diameter, or macrogeometry.[45] They also reported that at a constant diameter, the maximum stress value observed in the first six threads was equal or even lower in shorter implants (8.5 mm) than in longer ones.

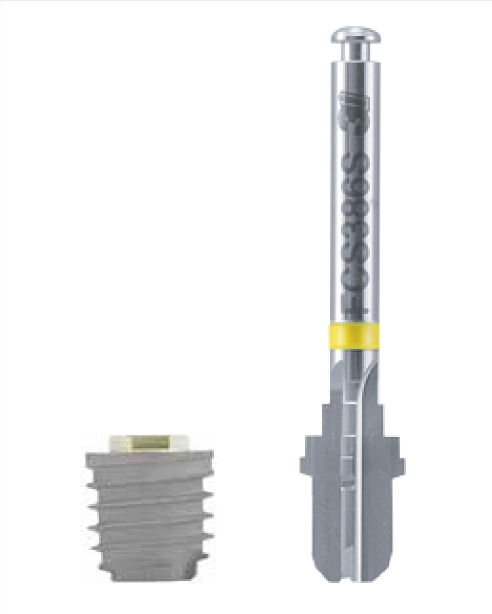

Fig. 4. T3® Short Implant and Final Shaping Drill
The last drill used before the insertion of a T3 Short Implant is a flat-bottom Shaping Drill, which is implant specific. It matches the exact shape of the implant without the threads to maximize the initial bone-to-implant contact and implant primary stability.

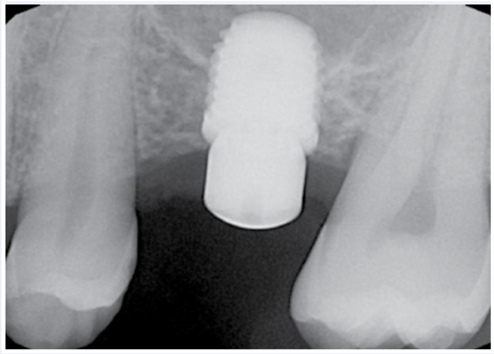

Fig. 5. A 5 mm diameter T3 Short Implant platform switched with a 4.1 mm diameter healing abutment.

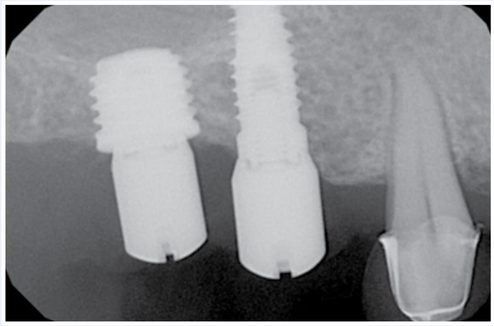

Fig. 6. A 6 mm diameter T3 Short Implant with a 4.1 mm diameter healing abutment (double platform switching).

Short implant placement guidelines

When placing short implants in areas of deficient bone height, following the recommended surgical protocols based on the bone type and using the original instruments and drills is critical to achieve good primary stability of the implants (Fig.4). Moreover, taking certain steps can increase the likelihood of long-term success. The author has developed the following guidelines:

Platform switching: After connection of implants to abutments and exposure to the oral environment, routine loss of approximately 1.5 to 2 mm of vertical bone has long been recognized to occur.[46] Such changes in the crestal bone can profoundly affect treatment outcomes; the discovery that significantly less peri-implant bone loss occurs when smaller diameter abutments are connected to larger diameter implants[47] was thus highly significant. Since then, platform switching has become widely accepted as an effective strategy for mitigating post-restorative peri-implant bone loss and increasing overall functional and aesthetic success. Given the fact that short implants are indicated for sites that are vertically deficient to begin with, preventing any additional bone loss is particularly important. When Telleman et al recently examined the impact of platform switching upon peri-implant bone remodeling around short posterior implants, they found it to be significantly effective.[48] In all cases, the author thus recommends connecting a smaller diameter abutment to short implants (Figs. 5-6).

Splinting: Splinting of short implant crowns is recommended in order to decrease lateral forces on the prosthesis and reduce stresses on the short implants.[49] This is true regardless of whether short implants exclusively have been placed or they are being used in combination with standard length implants. When Yilmaz et al compared the strain generated by splinted and non-splinted short implant crowns, they concluded that splinting may provide a more even strain distribution during functional loading.[50] While it is not possible to splint a single crown supported by a single short implant, an excellent 10-year cumulative survival rate (98.3%) recently was documented for short implants supporting single posterior crowns.[51] Lai et al concluded that a single crown supported by a short implant is a predictable treatment modality. However, as the survival rate for such implants placed in Type IV bone was lower (94%), they cautioned that short implants should be placed in Type IV bone with caution (Figs. 7-8).

Figs. 7, 8. Two T3® Short Implants splinted to a longer implant in a three unit bridge. Note the platform switching on the two T3 Short Implants and the crestal bone preservation one year after implant placement.

Fig. 9. **Recommended surgical drilling protocol for crestal placement of 5 mmD x 5 mmL T3 Short Implants.** See Surgical Manual ZBINSTMT3S for detailed instructions.

Underpreparation of the osteotomy: The closer contact between an implant and the surrounding bone that results from high insertion torque values (more than 50 Ncm) has been shown to result in more predictable results.[52] To achieve high insertion torques for short implants placed in Type III and Type IV bone sites, the author recommends underpreparation of the osteotomy following the recommended surgical drilling protocol (Fig. 9).

The crown/implant ratio: Placement of short implants in severely resorbed ridges often increases the crown/implant (C/I) ratio. Some studies have suggested this may lead to greater implant failure rates.[30] Some clinicians have considered the greater crown height to be a vertical cantilever that could increase the peri-implant bone stress[53] and eventually result in crestal bone loss, implant failures, or prosthetic complications.[54-56] However, recent studies have cast doubt upon these concerns. When Tawil et al followed 262 short, smooth-surfaced implants (for a mean of 53 months), they found no correlation between the C/I ratio or occlusal table and peri-implant bone loss. They concluded that even when the C/I ratio had increased by two to three times, it did not appear to be a biomechanical risk factor if the force orientation and load distribution were favorable. Others have also found that the C/I ratio does not appear to reliably predict implant survival.[57,58] Although the C/I ratio does not by itself represent a biomechanical risk factor, a very high ratio may lead to mechanical failures such as abutment screw loosening or fracture (Figs. 10-11).

Fig. 10. Two T3® Short Implants with a high crown/implant ratio are splinted in the same prosthesis to reduce biomechanical stress.

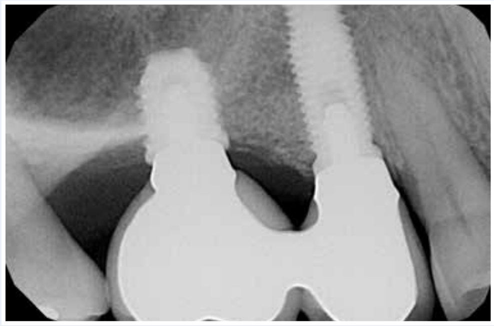

Fig. 11. A T3 Short Implant with an unfavorable crown/implant ratio splinted to a longer implant to distribute loading forces.

Staging of treatment: When short implants were first introduced, use of a staged approach was suggested, leaving the implants submerged to protect the initial phase of osseointegration and avoid the risk of implant failures due to micromovement or contamination.[59] However, patients often find it uncomfortable to wear removable provisional prostheses during the initial implant-integration phase. The ability to deliver a fixed prosthesis immediately after implant insertion is a major advantage.[60] Standard length implants placed in selected patients and immediately loaded have been shown to have survival rates comparable to those placed using standard staged procedures even in the presence of poor quality bone, if high insertion torque values (more than 40 Ncm) can be obtained during implant insertion.[52,61] The author believes the only indication for submerging short implants is an inability to achieve primary stability because of poor bone quality, for example, or inadequate osteotomy site preparation. In all other circumstances, a single-stage approach is preferable. If adequate insertion torque (>50 Ncm) can be achieved for each of the implants, immediate restoration with a healing abutment can be accomplished. When Cannizzaro et al in 2008 compared the outcomes of 7 mm-long implants that were immediately and early loaded, they found survival rates above 96% for both groups after nine months of loading, with no statistically significant differences between the two groups for implant losses, complications, mean marginal bone level changes, and patient preferences[62] (Figs 12-15).

Implant diameter selection: A minimum of 1 mm to 1.5 mm of bone should be maintained buccal to the implant to avoid buccal soft-tissue recession. Selection of the implant diameter should be based upon this criteria (Figs. 16-18).

Number of implants: In posterior partially edentulous cases, the rule of one implant per tooth should be applied for immediate loading cases. In full-arch cases, it is not necessary due to the cross-arch stabilization obtainable by splinting the provisional restoration (Figs. 19-21).

Connective tissue: An adequate band of keratinized tissue should be present around the implants. The significance of the presence of keratinized mucosa on long-term implant health has been well documented in the literature[63,64] (Fig. 22).

Figs. 12. Occlusal view of a case performed using flapless, single-stage approach with exposed healing abutments.

Figs. 13. Occlusal view after 4 months of healing.

Figs. 14. Clinical case including a standard length implant in the first premolar and two T3 Short Implants in the second premolar and first molar positions.

Figs. 15. The implants were placed in healed sites in a single stage procedure. A screw-retained bridge out of occlusion, was used as a provisional restoration.

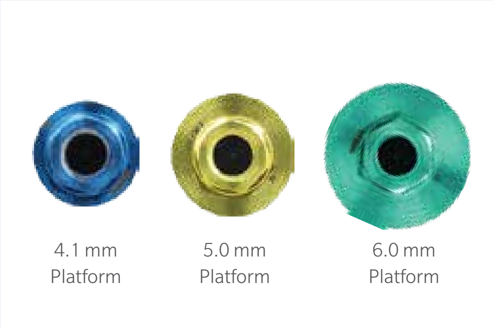

Fig. 16. Occlusal view of the restorative platform of a 4.0 mm D x 11.5 mm L Ex Hex Implant, a 5.0 mm D and a 6.0 mm D T3 Short Implant. The hex size is the same for all three implant diameters.

Fig. 17. Clinical case with a 4.0 mm diameter implant in the premolar site and a 5.0 mm diameter T3 Short Implant in the molar site, allowing for a minimum of 1 mm of buccal bone around both sites.

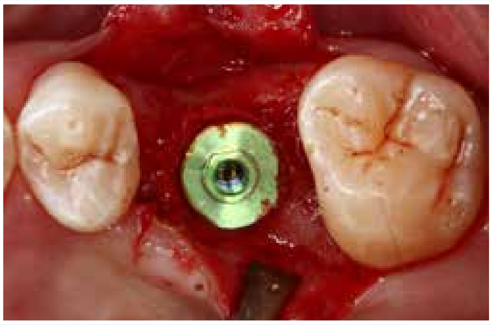

Fig. 18. Clinical case with a single 6 mm diameter T3® Short Implant with 1 mm to 2 mm of bone surrounding the implant.

Fig. 19. Posterior partially edentulous case with three T3 Short Implants in place. One implant per tooth was placed as immediate provisionalization was desired.

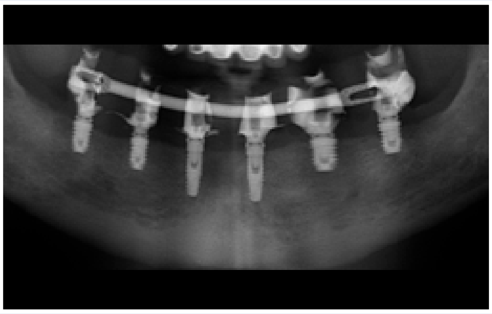

Fig. 20. Immediate loading of a full mandible with a fixed provisional prosthesis on six implants. The left quadrant posterior implants are two T3 Short Implants.

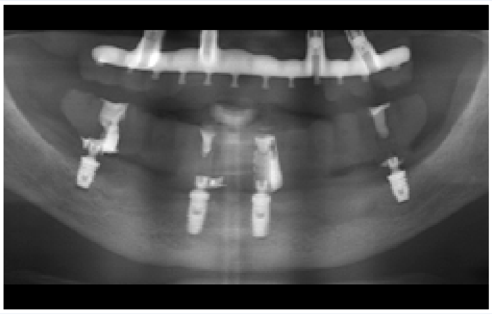

Fig. 21. Immediate loading of a full mandible with a fixed provisional prosthesis on four implants, with the two posterior implants being T3 Short Implants.

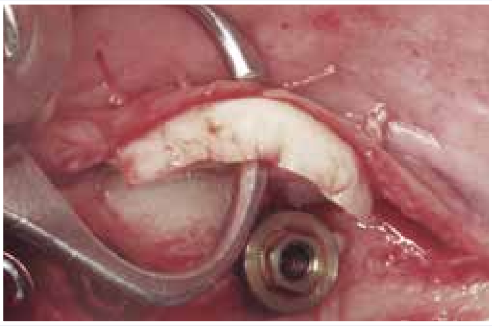

Fig. 22. Connective tissue graft in the buccal side around a T3 Short Implant to achieve an adequate thickness.

Conclusion

The use of short implants makes it possible to provide implant-supported restorations without the need to vertically augment atrophic ridges. The posterior zones can be restored in less time with less risk of complications normally associated with grafting procedures and with less treatment costs.

Francesco Amato, MD, DDS, PhD†

Dr. Francesco Amato completed his MD degree at the University of Catania, Italy in 1991. In 1992–1993 he completed a one year full time Advanced Program for International Dentists in Periodontics at New York University College of Dentistry followed by two years full time Advanced Program for International Dentists in Implant Dentistry at New York University College of Dentistry, 1993–1995. He completed his continuing Education Program in Implant Dentistry at New York University College of Dentistry, 1994–1995. He received his Ph.D. Biopharmaceutical Microbiology at the University of Catania, Italy, 1994–1997. He has published numerous articles in international journals; is a lecturer in National and International Conferences and Courses. He is in private practice specializing in Periodontics and Implant Dentistry in Catania, Italy, and is a Clinical Professor in the Master of Periodontology at Universitat Internacional de Catalunya, Spain, a Visiting Professor in the Department of Periodontology at Columbia University, New York, and an International lecturer for the Continuing Dental Education at New York University, New York.

†The contributing clinician has a financial relationship with Zimmer Biomet Dental resulting from speaking engagements, consulting engagements, and other retained services.

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