

“Macrogeometric Differentiation of Dental Implant Primary Stability: An In Vitro Study”

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Objective: Implant macrogeometry is one factor affecting implant primary stability. Bone density is accepted as a clinical guide for predicting implant primary stability. Classification systems by Lekholm and Zarb (I – IV) ¹ as well as Misch (D1-D4) ² have been used to characterize bone and, accordingly, there is broad consensus that type IV/D4 bone challenges the attainment of primary stability. A systematic review has affirmed a positive association with moderate to high correlation between implant primary stability and bone mineral density ³ represented among included studies. ⁴ Of particular concern is type IV bone for which higher implant failure rates have been recorded. ⁵ Solutions to this challenge have generally centered on improving implant primary stability in this low-density bone. Recent innovations include various threads designed to interact with bone upon implant insertion to increase primary stability measured by insertion torque or resonance frequency (ISQ). The goal of this study was to evaluate an alternative thread design using cutting and progressive thread design to increase primary stability in low density bone.

Materials and methods: Four different implants with different macrogeometries (Table 1) (Nobel Biocare Active Internal RP implants (4.3 x 11.5 mm), Straumann BLX Roxolid RB implants (4.5 x 10 mm), Astra Tech Implant EV implants (4.2 x 11 mm) and PrimeTaper (4.2 x 11 mm)) were obtained from the manufacturers and inserted into simulated osteotomies and extraction sockets in synthetic bone (Sawbones®) according to the manufacturers’ protocol. Lowest density solid foam blocks (10 PCF; Sku 1522-01), low density blocks (15 PCF; Sku 1422-01) and medium density blocks (20 PCF; Sku 1522-03) were selected to represent type 4 bone, type 3 bone and type 2 bone respectively (figure 1). All blocks were used as manufactured as 130 mm x 180 mm x 40 mm blocks without modification. The material is reported to possess a more uniform cell size than bone. Insertion torque and ISQ values were measured using Implantmed Plus motor and Ostell IDX, respectively. Insertion time was recorded. Average values were calculated and compared by ANOVA and Tukey’s test.

Results: Insertion torque (range 5 – 44 Ncm) increased with increasing synthetic bone density for all implants. Different ISQ values in synthetic low-density bone were not observed in higher density synthetic bone (figures 2, 3 and 4). Insertion torque of all implants was reduced when Implants were placed in simulated sockets compared to simulated osteotomies (figure 5). PrimeTaper implants with cutting, progressive thread design primary stability was equivalent to the NobelActive compressive thread design implant and greater than the BLX compressive thread design implant in both low density and higher density synthetic bone.

Conclusion: Different implant macrogeometries obtain relatively high primary stability in low density bone when measured by ISQ. Double thread implant designs reduce insertion times in higher density bone. A cutting and progressive compressing thread design provides density-sensing performance when compared with aggressive condensing thread designs. This macrogeometry can achieve high primary stability associated with modest insertion torque when compared with aggressive threaded implant designs known to attain highest insertion torque. The presence of multiple cutting threads may offer advantages in obtaining primary stability in low density bone.

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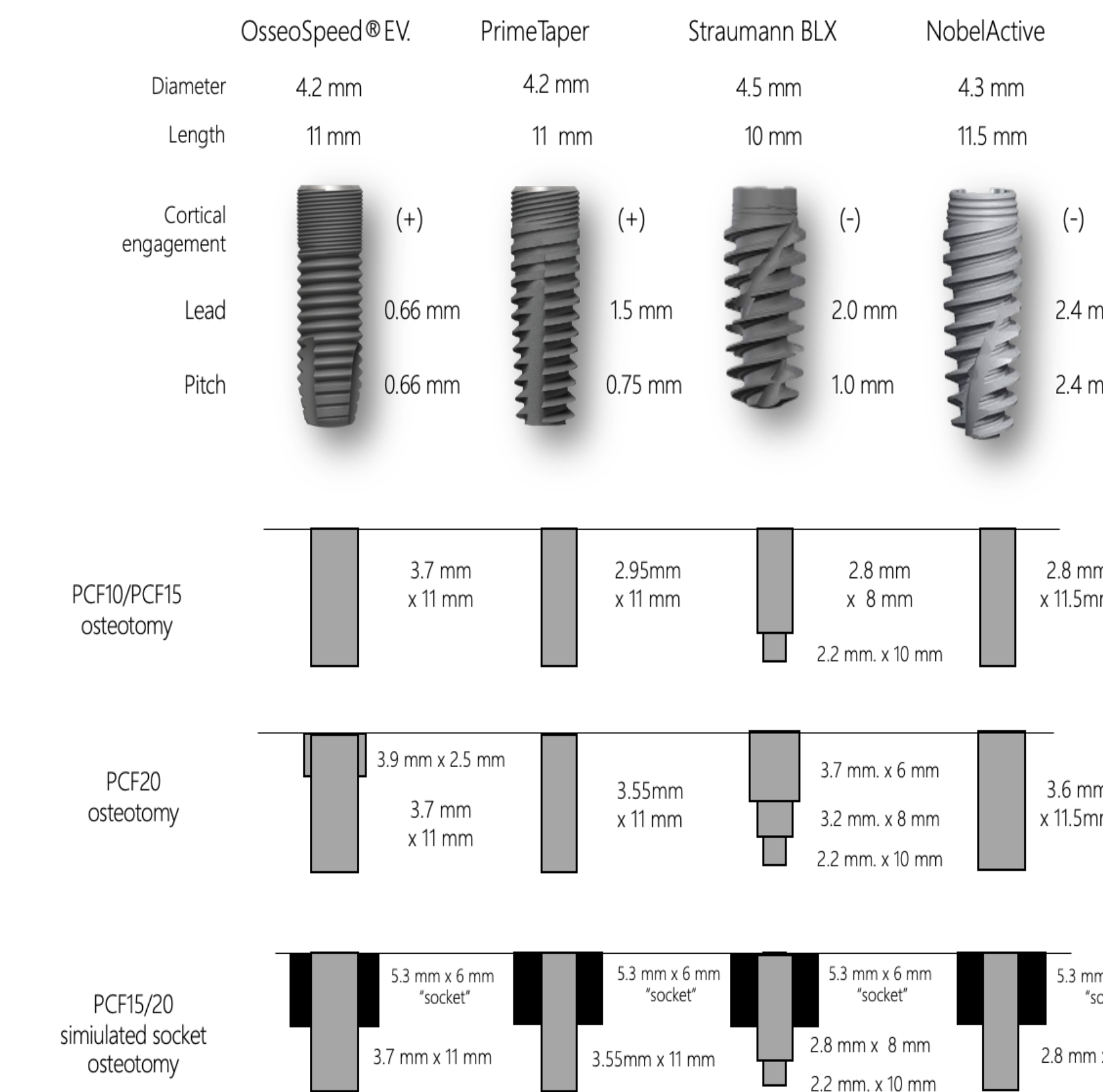


Figure 1. Implant macrogeometry and study-related osteotomy dimensions.

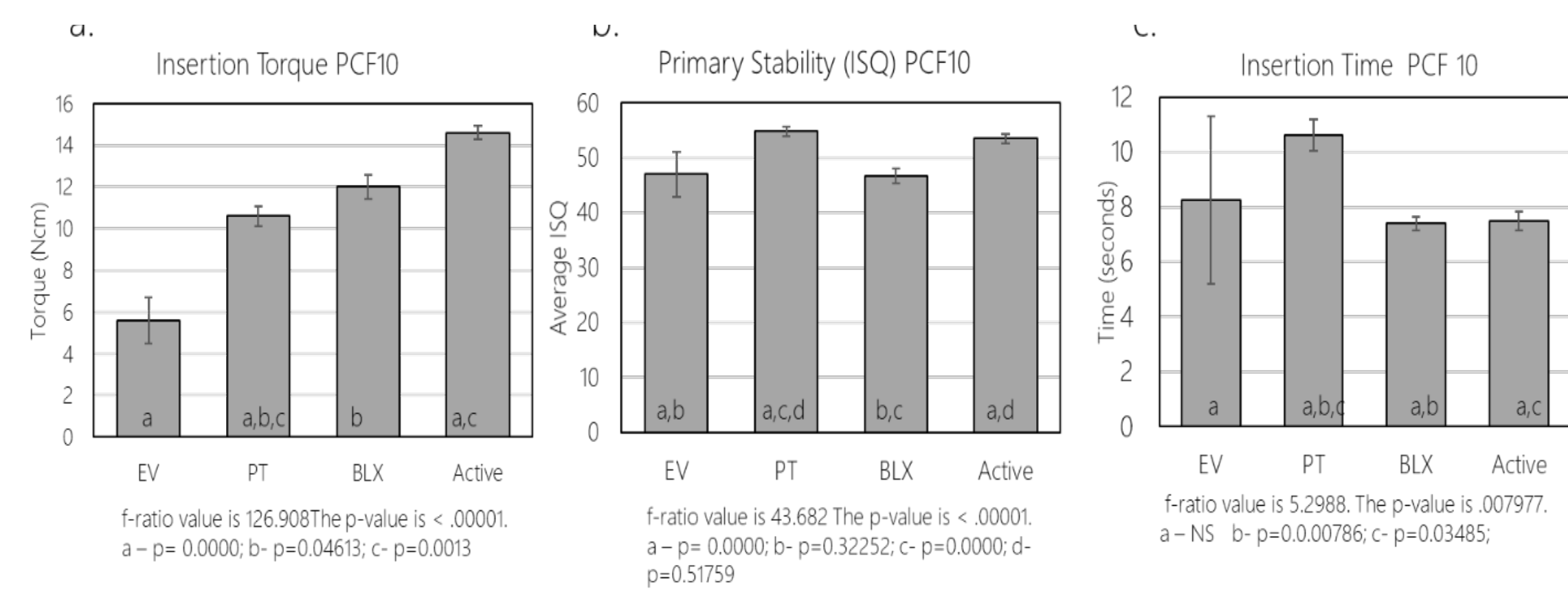


Figure 2: Comparison of implant insertion in PCF10 (D4) simulated bone. a) insertion torque, b) primary stability, and c) insertion time. Significant differences indicated (p<0.05).

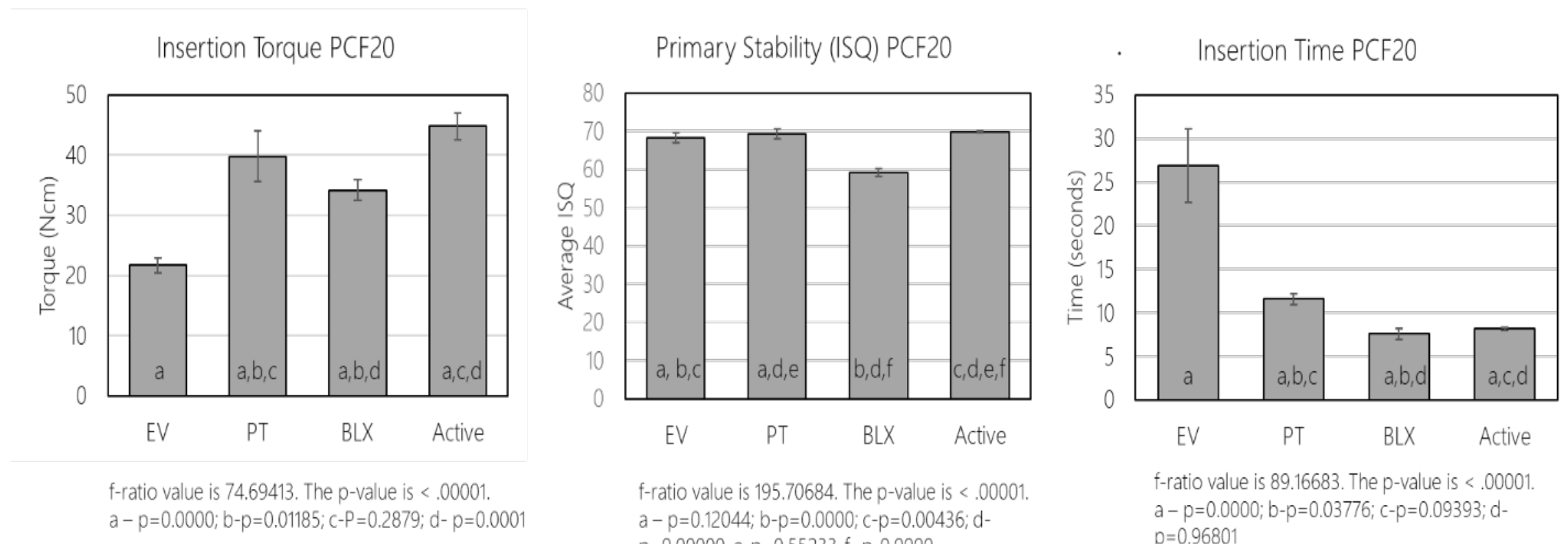


Figure 4: Comparison of implant insertion in PCF20 (D2-D3) simulated bone. a) insertion torque, b) primary stability, and c) insertion time. Significant differences indicated (p<0.05).

Implant	Dimension	Major thread design	Cortical thread design	Pitch/Lead
AstraTech Implant EV	4.2 x 11 mm	Symmetrical	Microthread	0.66 / 0.66 mm
Astra Tech PrimeTaper	4.2 x 11 mm	Variable thread design, Reverse buttress	Microthread	0.75 / 1.5 mm
BLX Straumann	4.5 x 10 mm	Variable thread design with distributing flutes	Reduced neck diameter, microthreads	1./ 2.2 mm
NobelActive	4.3 x 11.5 mm	Variable thread design, Condensing, reverse cutting flutes	Back-tapered, microthreads	1.2 / 2.4 mm

Table 1. Summary of implant systems used and their characteristics

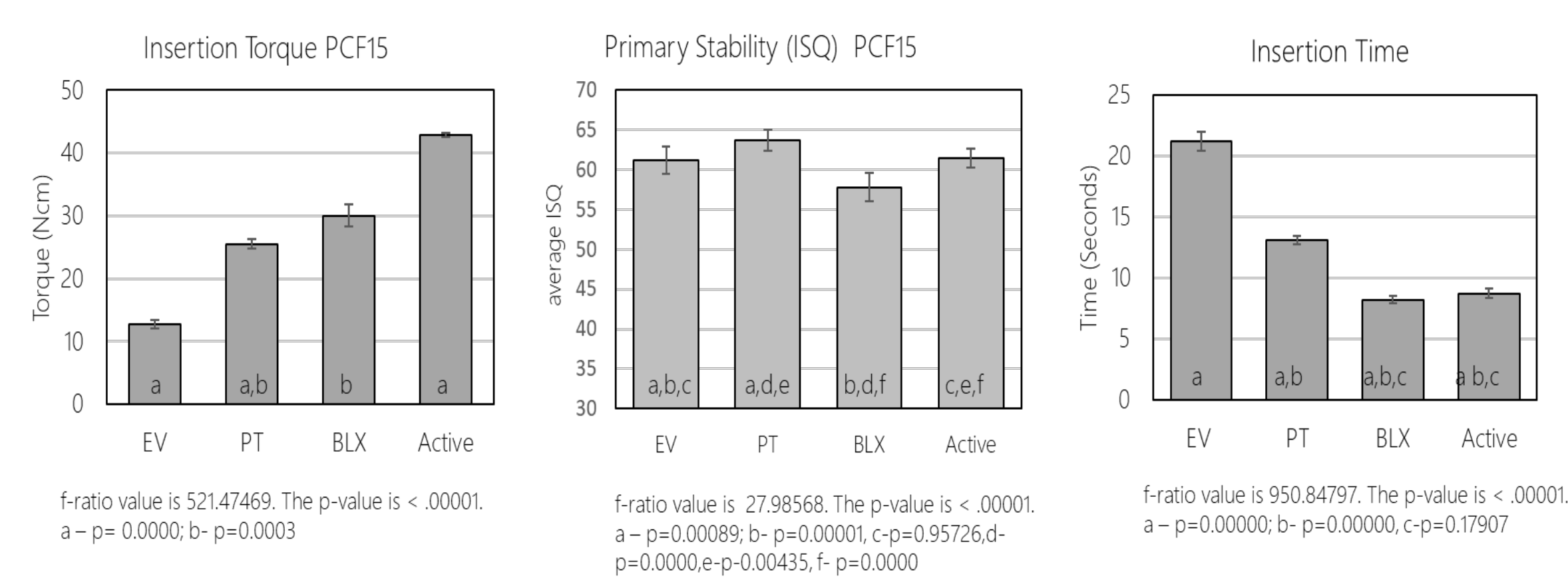


Figure 3: Comparison of implant insertion in PCF15 (D3-D4) simulated bone. a) insertion torque, b) primary stability, and c) insertion time. Significant differences indicated (p<0.05).

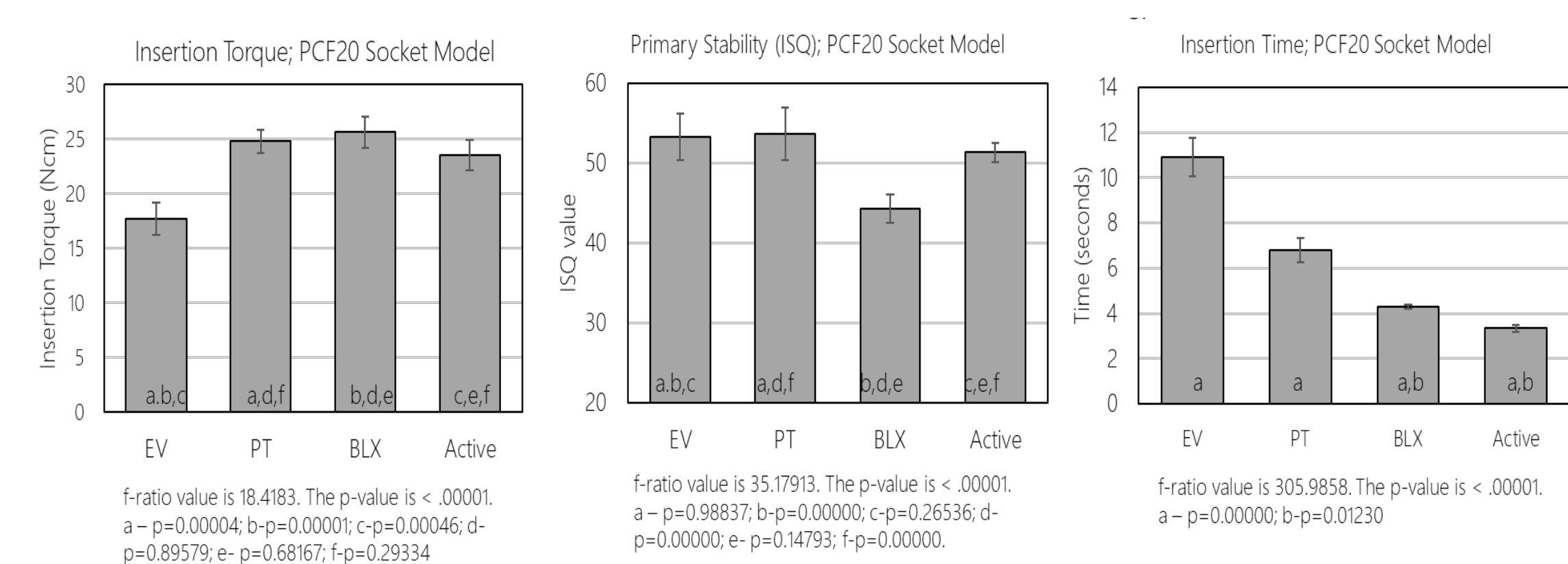


Figure 5: Comparison of implant insertion in socket defect in PCF20 (D3-D4) simulated bone. a) insertion torque, b) primary stability, and c) insertion time. Significant differences indicated (p<0.05).