Posterior tibial slope: the fingerprint of the tibial bone

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“Life is most delightful on the downward slope.”
–Lucius Annaeus Seneca the Younger

It is not only downhill bikers and alpine skiers who show great interest in a steep and sometimes slippery slope. No, in recent years also orthopaedic surgeons eagerly pursue the posterior tibial slope (PTS), seeking answers of its biomechanical and clinical impact in knee function.

Why is there so much hype about the so-called “tibial slope”? The PTS represents the posterior inclination of the proximal tibia, making the PTS a three-dimensional,

individual characteristic of the tibia. Given significant PTS differences amongst sexes (female > male), races (African > Caucasian), and even compartments (medial > lateral), the PTS may be referred to as the fingerprint of the tibial bone [13].

In 2004, two independent research facilities, one from the United States [5] and one from Germany [1], published landmark research on the effect of PTS-changing osteotomy on knee kinematics and contact mechanics. Consistently, it has been shown that an increase in PTS results in an anterior shift of the tibial resting position [1, 5]. Accordingly, it has been suggested that decreasing the PTS may improve anterior–posterior knee laxity in the anterior cruciate ligament (ACL) deficient knee [5]. The ingrowth of biomechanical knowledge of sagittal lower limb alignment gained from these landmark studies resulted in a surge of observational clinical studies focusing on PTS and ACL injury. It has been shown that high (steep) PTS is associated with an increased risk of primary and recurrent ACL injury [6, 9, 10, 14, 16]. Most remarkably, the association between high PTS and ACL injury was demonstrated in a study with the subtitle “*The Catastrophic Effect of Age and Posterior Tibial Slope*” [9]. The ACL graft failure rate was found to be 11-fold higher in adolescents (≤ 18 years old at time of ACL reconstruction) with a $\text{PTS} \geq 12^\circ$ when compared to adults undergoing ACL reconstruction with

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PTS < 12° [9]. The significantly higher ACL graft failure rate in adolescents with increased PTS demonstrates the catastrophic effect of PTS and age on ACL reconstruction.

Of course, every ACL surgeon intends to minimise the risk of ACL graft failure, particularly in young athletic patients. However, shall we really take action to modify the individual tibial fingerprint in patients with ACL injury? Or are we better off counselling patients regarding their increased risk of failure, look at different graft choices or potentially add in a lateral augmentation procedure? Or maybe smarter still, discuss a change in type, volume and intensity of sport participation? In the primary setting, these latter options may be a safer and more palatable offering, with the more aggressive osteotomy left for the revision or re-revision procedures. However, if we take a close look at the results from biomechanical labs around the world, there is no doubt that PTS reduction could be a reasonable consideration. Several well-designed biomechanical studies have found lower ACL graft forces after decreasing PTS [3, 7, 8, 15]. Following the biomechanical evidence, clinicians now perform anterior closing wedge high tibial osteotomy to combine ACL reconstruction with PTS reduction. Since 2014, a total of four studies investigating primary (one study) and revision (three studies) ACL reconstruction combined with PTS reduction high tibial osteotomy have been published [2, 4, 11, 12]. Satisfactory outcomes have consistently been reported in regards to postoperative anterior–posterior and rotatory knee laxity, patient-reported outcomes, and failure rates, after a minimum 2-year follow-up [2, 4, 11, 12]. However, it should be considered that the existing data are based on case series (i.e. no control group) with a total of 52 patients. In addition, long-term results have yet to be reported.

With this recent expansion of knowledge, PTS has worked its way to the forefront of ACL injury treatment. As orthopaedic surgeons, osteotomies are in our DNA; however, ideal indications for PTS reducing osteotomies still require refinement. The available evidence has taught us that anterior closing wedge high tibial osteotomy may lead to hyperextension [15]. This should be considered preoperatively, as iatrogenic creation of the extremely debilitating symptom of a hyperextension thrust must be avoided. The effect of PTS-changing osteotomy on native intra-articular structures such as the menisci or the posterior cruciate ligament are also largely unknown. Therefore, at the University of Pittsburgh, we felt compelled to investigate the impact of PTS change on these native intra-articular structures of the knee. In the future, this may help in selecting the ideal patient for PTS-changing osteotomy.

The incorporation of corrective coronal plane osteotomies into daily clinical practice amongst the orthopaedic community has taken not only excellent biomechanical and clinical research, but more importantly, years of experience.

Major efforts have succeeded and turned coronal plane corrective osteotomies into reliable and highly effective procedures that are now performed on a routine basis. Similarly, ongoing research efforts are devoted to determine precise indications for PTS corrective osteotomy. These efforts seek to present high-level evidence to introduce PTS corrective osteotomies to the daily clinical practice of every dedicated knee surgeon.

In conclusion, we recommend to assess the PTS in every patient with ACL injury. This information is extremely useful when counselling young patients as to their risk of re-injury and choice of surgical procedure. In second or multiple revision ACL reconstruction cases and when PTS is > 12°, PTS-decreasing high tibial osteotomies utilising supra-, trans-, or infra-tuberosity approaches could be considered to improve graft survivorship in the short term. We wait to see what advantages this may convey in the long term.

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