A Novel Technique for the Estimation of Gingival Thickness: A Preliminary Study

Serhat Aslan, DDS, PhD
Tommaso Clauser, DDS
Tiziano Testori, MD, DDS
Massimo Del Fabbro, MSc, PhD
Giulio Rasperini, DDS

This study aimed to evaluate the correlation between soft tissue thickness measured by CBCT and phenotype probing estimation and to assess the thickness cutoffs for each phenotype probing outcome. CBCT was performed with a lip retractor in order to isolate periodontal soft tissues in 10 consecutive patients. Using colored probes, the phenotype was evaluated for all present teeth and recorded as thin, medium, thick, or very thick. The overall correlation between tissue thickness and the phenotype probe score was $r = 0.86$ (CI: 0.80, 0.90). The correlation was $r = 0.90$ (CI: 0.81, 0.94) when only maxillary anterior teeth were considered. The obtained cutoffs were 0.83 mm between thin and medium phenotypes, 1.07 mm between medium and thick phenotypes, and 1.24 mm between thick and very thick phenotypes. Thus, a high correlation between tissue thickness and the phenotype probe score was found. Preliminary data on the use of phenotype probes as an evaluation method for gingival thickness were promising. Int J Periodontics Restorative Dent 2021;41:571–577. doi: 10.11607/prd.4947

Adequate soft tissue thickness is a key factor for success in periodontal surgery and implant rehabilitation. The need for a connective graft in coronally advanced flap for root coverage could vary on the basis of the original soft tissue thickness,1–4 and implant success in esthetic areas is strongly affected by soft tissue management and thickness.5–9 Direct measurement of the soft tissue thickness is complex, error-prone, and slow; this makes it unsuitable for a daily clinical use.10 Thus, different techniques have been proposed to overcome its limits. Ultrasonic systems have been developed,10,11 but the need for longer preparation, higher costs, and slow operative time have prevented its diffusion. A technique based on CBCT associated with a lip retractor has been suggested.7,12 Measuring soft tissue thickness is not an indication for a 3D radiographic examination, per se, and therefore, this system can be used for a limited number of cases, when 3D imaging is already required for other purposes. The use of optical coherence tomography has been described on animal specimens13 and even in vivo14 with promising results, but clinical application will need time.

As the described difficulties prevented clinicians from measuring the soft tissue thickness, some estimation techniques have been developed. The correlation between soft tissue thickness and phenotype probing outcome has been found. Preliminary data on the use of phenotype probes as an evaluation method for gingival thickness were promising. Int J Periodontics Restorative Dent 2021;41:571–577. doi: 10.11607/prd.4947

1Private Practice, İzmir, Turkey; Department of Biomedical, Surgical and Dental Sciences, University of Milan, Milan, Italy.
2Department of Biomedical, Surgical, and Dental Sciences, University of Milan, Milan, Italy; IRCCS Orthopedic Institute Galeazzi, Milan, Italy.
3IRCCS Orthopedic Institute Galeazzi, Dental Clinic, Section of Implantology and Oral Rehabilitation, Milan, Italy; Department of Biomedical, Surgical, and Dental Sciences, University of Milan, Milan, Italy; Department of Periodontics and Oral Medicine, School of Dentistry, University of Michigan, Ann Arbor, Michigan, USA; Private Practice, Como, Italy.
4Department of Biomedical, Surgical and Dental Sciences, University of Milan, Milan, Italy; Foundation IRCCS Ca’ Granda Polyclinic, Milan, Italy.

Correspondence to: Dr Massimo Del Fabbro, University of Milan, IRCCS Orthopedic Institute Galeazzi, Via Riccardo Galeazzi 4, 20161, Milan, Italy.
Email: massimo.delfabbro@unimi.it

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proposed. The first method used was a visual evaluation of the phenotype thickness. Kan et al found that the evaluation of the transparency of a yellow/black plastic periodontal probe through free gingiva was more predictive than visual evaluation. The limit of this technique is that the result is dichotomous: When the probe is visible, the predictive value registered is 83%, but when probe is not visible, the predictive value of a thick phenotype (> 1 mm) drops to 70%. Later, De Rouck et al developed a method based on the sum of the evaluation of the two central incisors; in this way, a person’s phenotype could be categorized at three different levels. Unfortunately, the phenotype is related to some site-dependent variables, such as malposition or recession, and these two teeth must be present to have external validity.

To overcome these limits, phenotype probes have been designed. These probes categorize the phenotype of a single site in one of four categories. The phenotype probe has been used in a study by Rasperini et al to evaluate the correlation of phenotype and gingival recession during orthodontic treatment and, in two studies, to select thin and very thin phenotypes for a graftless tunneling procedure and to correlate the outcome of coronally advanced flap in different phenotype sites. So far, no comparison has been made between this estimation technique and a measurement of soft tissue thickness.

Therefore, the aim of this study is (1) to evaluate the correlation between soft tissue thickness measured by CBCT and phenotype estimation by probing, and (2) to assess the thickness cutoffs for each phenotype probing outcome.

Materials and Methods

The study protocol was approved by the institutional review board of the IRCCS Galeazzi Orthopedic Institute (protocol no. L2057).

The records of 10 consecutive patients requiring a CBCT scan for implant therapy were retrieved. These patients presented 105 teeth overall, of which 77 were located in the maxilla and 28 were located in the mandible; 40 were part of the maxillary anterior sextant (incisors and canines), 11 in the mandibular anterior sextant (incisors and canines), 38 were premolars, and 16 were molars.

CBCT scans were taken according to Januário et al. Briefly, a lip retractor was placed upside down in order not to interfere with the chin rest during the acquisition of the scan, allowing the tissue thickness to be measurable on the computer.

Probing was performed on all present teeth with phenotype probes (Colorvue Biotype Probes, Hu-Friedy). The phenotype was defined as thin when the white probe was visible through the gingival margin. If the white probe was not visible, the green probe was used: If it was visible through the gingiva, the phenotype was defined as medium. If the green probe also was not visible, the blue probe was used: The phenotype was defined as thick when it was visible and very thick when it was not visible (Fig 1).

CBCT scan measurements were performed 2 weeks after clinical evaluation using One Volume Viewer (Morita; Fig 2). In the most central cross-section of the selected tooth, the axis of the tooth was found, and a perpendicular line passing 1 mm apical to the free gingival margin was noted. On this line, the distance between the root and the gingival surface was measured. The correlation between CBCT-measured thickness and the phenotype score was assessed using Pearson correlation coefficient, reported with 95% confidence intervals (95% CIs; R software, R Core Team). For statistical analysis, instead of the category names thin, medium, thick, and very thick, integers were used (1, 2, 3, and 4, respectively). Cutoff values for each score were calculated using the Youden index and the receiver operating characteristic (ROC) analysis (ROCit package, R software) comparing thin with medium, medium with thick, and thick with very thick phenotypes.

The analysis was first performed on all present teeth, then repeated for maxillary incisors and canines only. The cutoff assessment (ROC analysis) was not performed if the compared groups did not reach ≥ 10 teeth each.

Results

Data were recorded from six women and four men. The patients’ mean age at time of diagnosis was
30.34 years (range: 17 to 48 years). Phenotype probe scores resulted in 44 teeth with a thin phenotype (18 in the maxillary anterior sextant), 30 with a medium phenotype (9 in the maxillary anterior sextant), 12 with a thick phenotype (5 in the maxillary anterior sextant), and 19 with a very thick phenotype (8 in the maxillary anterior sextant). The average CBCT-measured thickness was 0.98 mm (SD: 0.32 mm).

Overall correlation between tissue thickness and the phenotype probe score was high ($r = 0.86$; CI: 0.80, 0.90). When only maxillary anterior teeth were considered (teeth 13 to 23 [FDI tooth numbering system]), the correlation was $r = 0.90$ (CI: 0.81, 0.94).

Area under the curve was 0.94 when comparing thin to medium phenotypes, 0.84 when comparing medium to thick phenotypes, and
0.97 when comparing thick to very thick phenotypes (Fig 3).

A thickness of 0.83 mm resulted in the highest Youden index when comparing thin and medium phenotypes, 1.07 mm when comparing medium and thick phenotypes, and 1.24 mm when comparing thick and very thick phenotypes (Figs 3 and 4).

**Discussion**

According to the data collected in this cross-sectional pilot study with retrospective recruitment, phenotype probes are a valid method for estimation of phenotype thickness. Correlation between soft tissue thickness measured by CBCT and phenotype estimation by probing was higher when considering only the maxillary anterior sextant data. This could be due to two factors: more limited patient data and a lower range of variation for thickness. In fact, the “very thick” category has more variability when posterior teeth are considered. Rank correlation

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**Fig 3** Receiver operating characteristic (ROC) curves for (a) thin vs medium phenotypes, (b) medium vs thick phenotypes, and (c) thick vs very thick phenotypes.
statistics (Spearman, Kendall tau-b) could be used in order to avoid this effect; the fact that the correlation is still high means that the intermediate phenotype categories (medium and thick) have a similar range.

This observation is supported by cutoff assessment: A thin phenotype is likely to be associated with soft tissue thickness < 0.83 mm (best sensibility and specificity values); medium phenotype is associated with gingival thickness ≥ 0.83 mm and < 1.07 mm (range: 0.24 mm), and thick phenotype is associated with gingival thickness ≥ 1.07 mm and < 1.24 mm (range: 0.17 mm).

The empirical ROC curve is designed so that—for each result of a diagnostic test with a continuous outcome—the sensibility and specificity of the test are assessed in relation with a dichotomous value,
representing a situation/illness that has already been assessed by the use of a gold-standard diagnostic test. In this case, the continuous value was the CBCT-measured soft tissue thickness and the dichotomous value was the phenotype probing outcome, so that the sensibility and the specificity refer to the ability of the gingival thickness to predict the phenotype probe outcome. This led to a reversed contingency table, meaning that when the phenotype probing outcomes are considered as a diagnostic test, the sensibility of the “reversed” test is actually the positive predictive value, and the specificity is the negative predictive value. Because predictive values are affected by the prevalence of a situation, it is assumed that the distribution of gingival thickness in this sample is similar to the distribution in the general population.

In the present dataset, no gingival thickness estimation error of two categories occurred. In other words, if a thin phenotype was reported, it was impossible for the CBCT gingival thickness to be in the range of the thick or very thick phenotype, and vice versa.

In a study by Kloukos et al, the phenotype probes were studied and assessed according to the gingival-thickness estimation method. In that study, phenotype probes were compared to direct measurements by means of a periodontal probe, an acupuncture needle, and an ultrasound device on both mandibular central incisors of 200 orthodontic patients. Cutoff values were not assessed. Predicted thickness values in Kloukos et al were lower than the cutoff measurements in the present study; this could be due to the sample selection, as mandibular incisors are likely to have a thinner phenotype than other teeth, especially in younger patients. A higher prevalence of thin phenotypes could affect predicted values, jeopardizing the external validity of these findings to the full dentition. In addition, the phenotype probing assessments were made by inserting the probe 1 mm into the gingival sulcus, while direct measurements were made 2 mm apical to the gingival margin. This may also affect the outcomes.

This study has some limitations due to the small sample size and retrospective data collection. A multi-level analysis was not possible; thus, considering the tooth as sample unit led to a spurious sample-size increment if the patient level influences the thickness evaluation.

The present results should be confirmed by studies with prospective recruitment, a bigger sample size, and a complete analysis, considering how setting, operator, and patient factors could influence the phenotype probing results. Such studies should also evaluate whether using CBCT scans is reliable for measuring gingival thickness.

Another limitation is that CBCT-measured thickness was assumed to be a reliable reference standard. Alves et al concluded that CBCT-measured thickness presents acceptable values of reliability and can be considered clinically useful to classify thick biotype (agreement: 86.1%; k = .51). However, Alves et al’s measurement location was more apical than in the present study (2 mm + probing depth); this could reduce the validity of the findings when measurements are performed 1 mm apical to the free gingival margin, as done in the present study.

Direct measurement of gingival thickness is difficult and invasive. Alternative estimation methods could help evaluate how this parameter could influence periodontal and peri-implant health and therapies. Because the phenotype probes are cheap, easy, and less invasive, they could be used in daily clinical practice, considering the growing evidence on the importance of gingival thickness in periodontal and peri-implant therapies.

Conclusions

Preliminary data on the use of phenotype probes as an evaluation method for gingival thickness were promising. More data are needed to confirm these results and to evaluate the influence of setting, patient, and site on the estimation.

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The authors declare no conflicts of interest.

References


