# Classification of Bone Demineralization Patterns using HR-pQCT Texture Metrics

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## Introduction

High-resolution peripheral quantitative computed tomography (HR-pQCT) can detect changes in bone microarchitecture, enabling phenotyping of bone demineralization patterns [1]. However, standardized texture analysis parameters [2] are multidimensional and may be challenging to interpret for an individual patient.

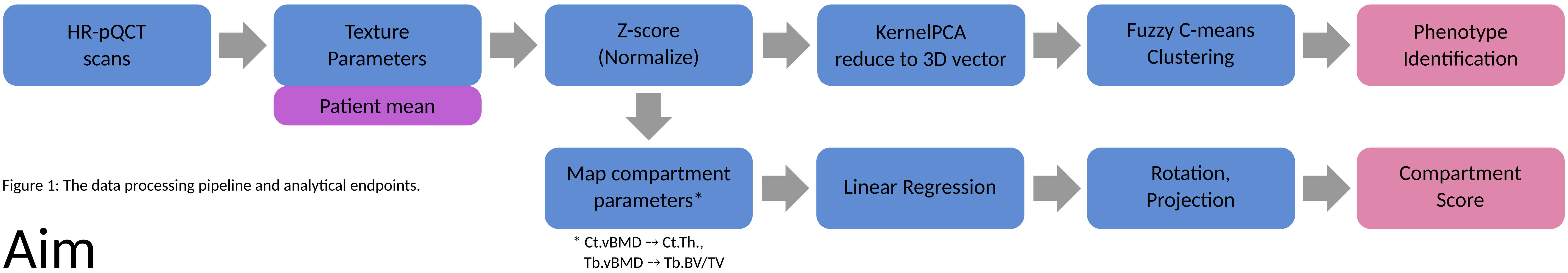


Figure 1: The data processing pipeline and analytical endpoints.

## Aim

To enable intuitive assessment of bone quality in individual patients, we propose **two composite scores summarizing trabecular and cortical bone deterioration patterns**.

Our goal is to provide a texture-based scoring system that remains intuitive and comparable across patients.

## Methods

In our analysis, we combined patient data from a study on post-stroke osteopathy (part of STROKE-CARD registry, Clinicaltrials.gov NCT04845269, **97 patients**) and a study on fracture healing (Clinicaltrials.gov NCT04783337, **94 patients**) for a total of **192 individuals** with multiple **(4–6) HR-pQCT scans** of the **distal radius** over the course of **12 months.**

Figure 1 shows the data processing pipeline. Texture parameters are averaged per patient and normalized for age and sex using demographic data provided by Warden et al. [3]. Using kernel PCA, the data were reduced to three dimensions before applying fuzzy c-means clustering (see Figure 2).

Based on the cluster distribution, we propose composite scores per bone compartment as a projection onto a linear regression line fitted to the distributions of Tb.BV/TV vs. Tb.vBMD and Ct.Th vs. Ct.vBMD, respectively, shown in Figure 3.

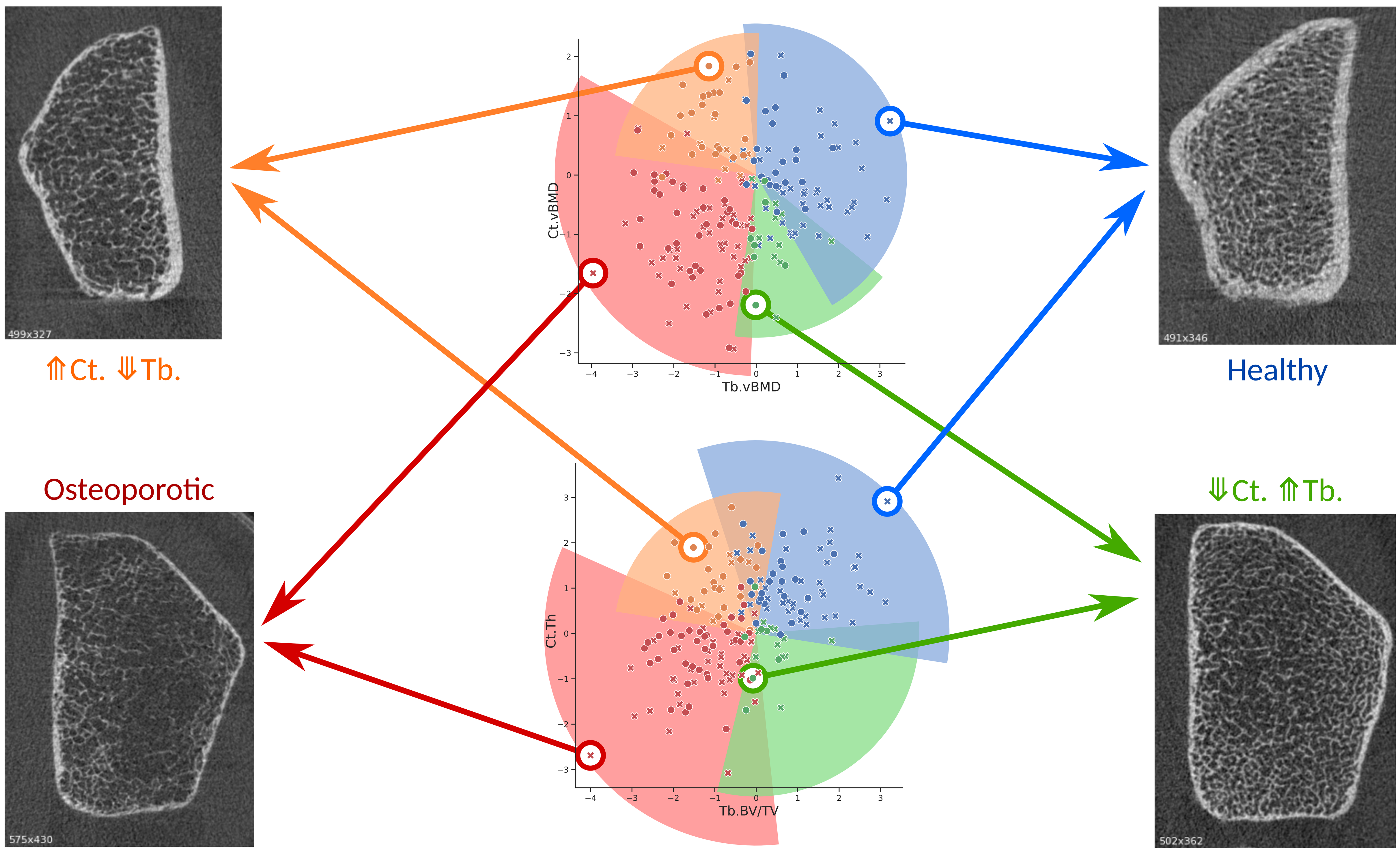


Figure 2: Clustering after kPCA on data separated by gender and bone compartment reveals potential bone structure phenotypes. Each data point represents an individual patient and was normalized to Z-scores according to Warden et al. [3]. As a guide to the eye, the colored segments indicate the approximate extent of clusters, relative to the origin. Representative HR-pQCT cross-sections are shown for selected data points.

## Results

We identify three potential bone loss phenotypes, as shown in Figure 2:

(1) generalized demineralization,

(2) trabecular deterioration, and

(3) cortical thinning.

We also propose composite scores for trabecular and cortical bone compartments (Figure 3).

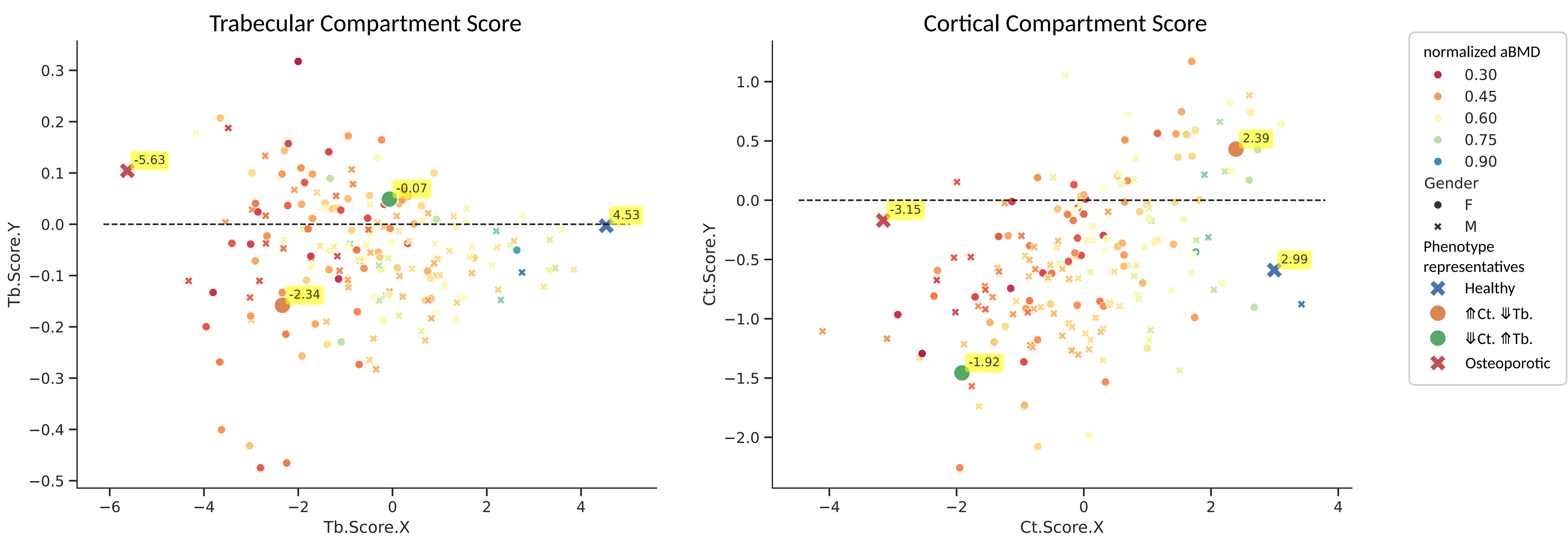


Figure 3: The proposed scoring approach for trabecular (left) and cortical (right) bone compartments. Highlighted data points correspond to the representative scan cross-sections in Figure 2, with the respective scores shown in the callouts.

## Conclusion

HR-pQCT texture analysis may aid characterization of distinct demineralization patterns that are not discernible by areal BMD measurement. Preliminary results support development of interpretable trabecular and cortical composite scores for future validation.

## References

[1] Whittier DE et al., 2020, J. Bone Miner. Res.

[2] Whittier DE et al., 2022, Osteoporos. Int.

[3] Warden SJ et al., 2022, Osteoporos. Int.

## Acknowledgements

We would like to thank Kerstin Stock and Benjamin Dejakum for providing the patient data from their respective studies.

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