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## RESEARCH LETTER

# Predicting Technical Success of Chronic Total Occlusion Percutaneous Coronary Intervention Comparison of 3 Scores

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The success of chronic total occlusion (CTO) percutaneous coronary intervention (PCI) significantly increased from 77% between 2000 and 2011<sup>1</sup> to 85% to 90% currently at experienced centers and depends on center and operator experience and lesion characteristics. Several CTO PCI scoring systems have been developed to assess procedural difficulty. The first one was the Japan chronic total occlusion (J-CTO) score that estimates the likelihood of successful guidewire crossing within the first 30 minutes based on 5 variables: blunt stump, calcification, lesion tortuosity, prior failed attempt, and occlusion length  $\geq 20$  mm.<sup>2</sup> Another widely used score is the Prospective Global Registry for the Study of Chronic Total Occlusion Intervention (PROGRESS-CTO) score that uses 4 angiographic characteristics: moderate/severe proximal vessel tortuosity, proximal cap ambiguity, circumflex coronary artery CTO, and absence of interventional collaterals to predict technical success.<sup>3</sup> The EuroCTO CASTLE score utilizes 6 variables for assessing the likelihood of success: prior Coronary artery bypass graft surgery, age ( $\geq 70$  years), stump anatomy (blunt or invisible), tortuosity degree (severe or unseen), length of occlusion ( $\geq 20$  mm), and extent of calcification ( $>50\%$  of the segment).<sup>4</sup>

We compared the aforementioned 3 scores for predicting technical success in 3757 CTO PCIs performed in 3757 patients enrolled in the PROGRESS-CTO Registry (REGISTRATION: URL: <https://www.clinicaltrials.gov>; Unique identifier: NCT02061436) between 2016 and 2020 at 27 US and 3 international centers. The

study was approved by the institutional review board of each site. The cases used to derive the PROGRESS CTO score were excluded from this analyses. The study data will not be made publicly available.

Mean age was  $64.1 \pm 10$  years, most patients were men (81%), 41% had history of diabetes, 28% had a history of prior coronary artery bypass graft surgery, and 30% had congestive heart failure. The most common target vessel was the right coronary artery (53%), followed by the left anterior descending coronary artery (27%), and the left circumflex (20%). Technical and procedural success was 84.9% and 82.7%, respectively and the incidence of major cardiac adverse events was 1.73%. The mean scores were as follows: J-CTO:  $2.40 \pm 1.30$ , PROGRESS-CTO:  $1.28 \pm 1.02$ , and CASTLE:  $2.05 \pm 1.33$ . Technical success was lower for higher values of all 3 scores (Figure [A]). The discriminatory performance of the 3 scoring systems in predicting the technical success of CTO PCI was evaluated comparing areas under the receiver operator characteristics curves (Figure [B]) and multivariable models (Figure [C]). The areas under the receiver operator characteristics curves were compared using a nonparametric approach by DeLong et al.<sup>5</sup> All 3 scores performed moderately well: in the score, only model the J-CTO score demonstrated the highest discriminatory capacity (areas under the receiver operator characteristics curve, 0.77 [95% CI, 0.75–0.79]), followed by the CASTLE score (areas under the receiver operator characteristics curve, 0.76 [95% CI, 0.74–0.78];  $P=0.05$  versus J-CTO score) and the PROGRESS-CTO

**Key Words:** coronary artery bypass ■ heart failure ■ incidence ■ percutaneous coronary intervention ■ registries

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## Nonstandard Abbreviations and Acronyms

<b>CTO</b>	chronic total occlusion
<b>J-CTO</b>	Japan chronic total occlusion
<b>PCI</b>	percutaneous coronary intervention
<b>PROGRESS-CTO</b>	Prospective Global Registry for the Study of Chronic Total Occlusion Intervention

score (areas under the receiver operator characteristics curve, 0.71 [95% CI, 0.69–0.73],  $P < 0.001$  versus J-CTO and CASTLE scores). The PROGRESS-CTO score which contains only angiographic characteristics and includes the fewest variables had slightly lower specificity.

The main finding of our study is that the PROGRESS-CTO, the J-CTO, and the CASTLE CTO scores perform moderately well in predicting the technical success of CTO PCI with the J-CTO score having the best overall performance. CTO PCI scores can be very useful for periprocedural planning and risk-benefit assessment in contemporary CTO PCI practice.

Our study has limitations. First, it was an observational, retrospective study. Second, there was no clinical event adjudication by a clinical events committee. Third, all procedures were performed at high-volume, experienced PCI centers, limiting the generalizability of the findings to nonexpert centers.

## ARTICLE INFORMATION

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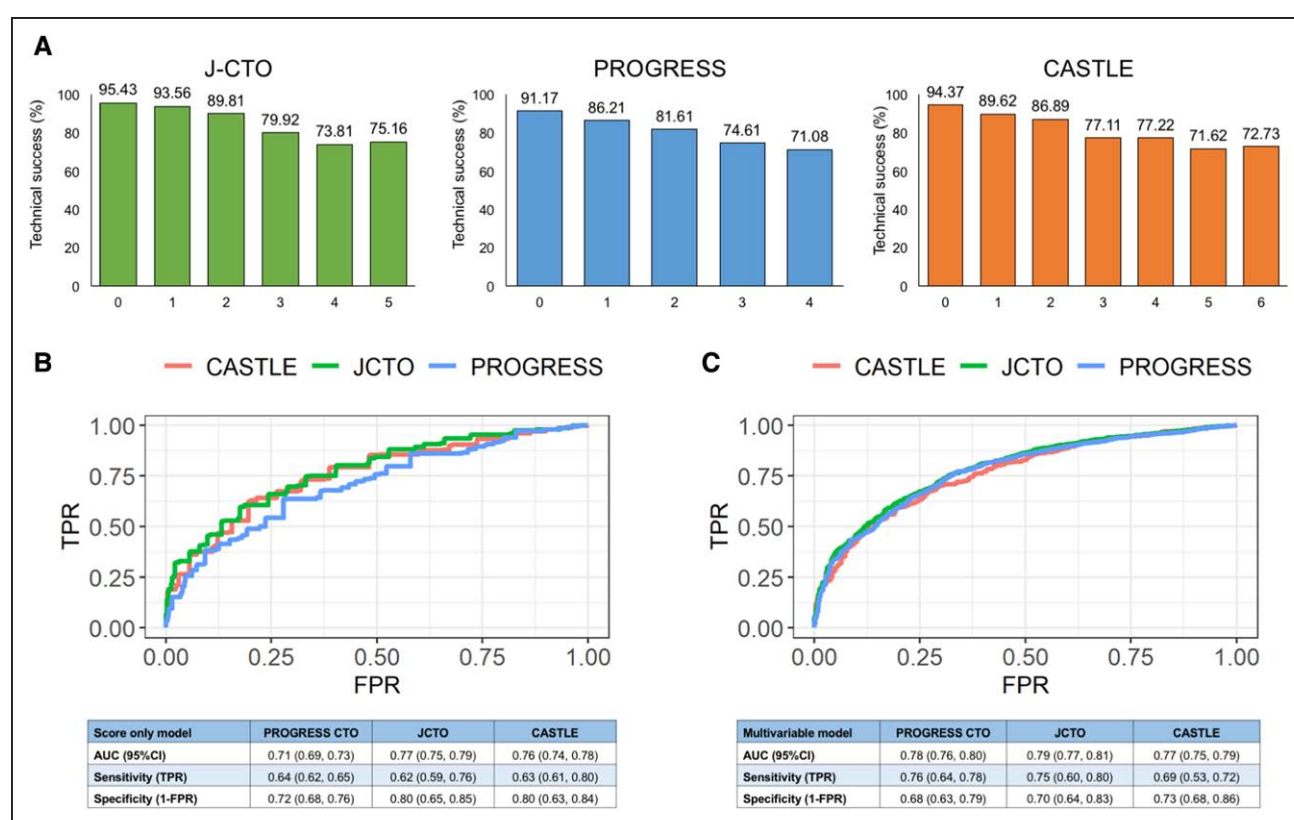
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**Figure. Technical success and receiver operator characteristics (ROC) curve analyses of chronic total occlusion percutaneous coronary intervention scores.**

**A**, Technical success of chronic total occlusion (CTO) percutaneous coronary intervention across Japan chronic total occlusion (J-CTO), Prospective Global Registry for the Study of Chronic Total Occlusion Intervention (PROGRESS-CTO), and CASTLE score strata. **B**, ROC curve analyses based on risk scores alone for CASTLE, J-CTO, and PROGRESS-CTO scores. **C**, ROC curve analyses based on multivariate models for CASTLE, J-CTO, and PROGRESS-CTO scores. EuroCTO CASTLE score: prior coronary artery bypass graft surgery, age, stump anatomy, tortuosity degree, length of occlusion, and extent of calcification. AUC indicates area under the receiver operator characteristics curve; FPR, false positive rate; and TPR, true positive rate.