Comparision between Direct Stenting and Stenting after Pre-dilatation Using TIMI Frame Count in Stable Coronary Artery Disease

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ABSTRACT

Introduction: There are limited data comparing the effects of direct stenting and stenting after balloon percutaneous transluminal coronary angioplasty (PTCA) on coronary flow in patients with stable coronary artery disease (CAD). This study was designed to evaluate the effects of direct stenting and stenting after balloon PTCA on coronary flow using TIMI frame count (TFC) in patients with stable CAD.

Patients and Methods: After a retrospective review of patients who underwent percutaneous coronary intervention (PCI) from 2008 to 2012, we identified and included 55 patients who underwent direct stenting and 42 patients who received stenting after balloon PTCA. PCI records of the two study groups were reviewed to re-calculate pre- and post-PCI TFCs for comparison.

Results: The average pre- and post-procedural TFC values were 18.72 frames per second (fps) and 16.12 fps (difference 2.6 fps), respectively, in the direct stenting group. The corresponding TFC values were 18.13 fps and 16.63 fps (difference 1.5 fps) in the stenting after balloon PTCA group. The two groups differed significantly with respect to post-procedural decreases in TFC ($p< 0.001$).

Conclusion: Our findings show that, compared to stenting after balloon PTCA, direct stenting is more successful in terms of improved antegrade coronary blood flow in stable CAD patients, which suggests that direct stenting may contribute to better microvascular circulation.

Key Words: Percutaneous coronary intervention; angioplasty; direct stenting

Stabil Koroner Arter Hastalığında Doğrudan Stentleme ve Ön-dilatasyon Sonrası Stentleme Yöntemlerinin TIMI Kare Sayısı Kullanılarak Karşılaştırılması

ÖZET

Giriş: Stabil koroner arter hastalığında doğrudan stent ve perkütan translüminal koroner anjiyoplasti (PTKA) sonrasında stentleme yöntemlerinin koroner kan akımı üzerine etkisini karşılaştıran yeterli veri yoktur. Çalışmamızda, doğrudan stent ve PTKA sonrası stentleme yöntemlerinin koroner kan akımı üzerine etkisi TIMI kare sayısı (TKS) kullanılarak karşılaştırıldı.

Hastalar ve Yöntem: 2008-2012 yılları arasında perkütan koroner girişim (PKG) yapılan hastalar taranarak, doğrudan stentleme uygulanmış 55 hasta ve PTKA sonrası stentleme uygulanmış 42 hasta çalışmaya alındı. Hastaların PKG kayıtları izlendi. Her hasta için işlem öncesi ve sonrası TKS hesaplandı. İki tedavi grubu işlem öncesi ve sonrası TKS açısından karşılaştırıldı.

Bulgular: Doğrudan stent grubunda ortalama TKS işlem öncesinde 18.72 kare/saniye, işlem sonrasında 16.12 kare (fark 2.6 kare/saniye) bulundu; PTKA sonrası stent grubunda ise bu değerler sırasıyla 18.13 kare/saniye ve 16.63 kare/saniye (fark 1.5 kare/saniye) idi. İşlem sonrası TKS'deki azalma açısından iki grup arasındaki fark anlamlı idi ($p< 0.001$).

Sonuç: Bulgularımız, stabil koroner arter hastalığında doğrudan stentleme yönteminin koroner kan akımını iyileştirmede PTKA sonrası stentlemeye göre daha başarılı olduğunu gösterdi. Bu bulgu, doğrudan stentleme ile daha iyi mikrovasküler dolaşım sağlandığını düşündürmektedir.

Anahtar Kelimeler: Perkütan koroner girişim; anjiyoplasti; doğrudan stentleme

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INTRODUCTION

It is known that shorter fluoroscopy time, fewer periprocedural complications and shorter processing time can be obtained with direct stenting in percutaneous coronary intervention (PCI) [1,2]. Thrombolysis In Myocardial Infarction (TIMI) frame count (TFC) is a quantitative parameter for the evaluation of antegrade coronary blood flow. In some small studies, in which ST-segment elevation acute myocardial infarction (STEMI) patients were included, lower TFC was found with direct stenting, and this was accepted as a marker for better antegrade coronary blood flow[3]. On the other hand, in stable coronary artery disease (CAD), there has been no clear data on the use of TFC for the evaluation of results with direct stenting. The aim of this study was to compare the effect of direct stenting and stenting after balloon percutaneous transluminal coronary angioplasty (PTCA) on antegrade coronary blood flow in stable CAD by using TFC. This comparison would provide more insight into the question of whether direct stenting was associated with better antegrade coronary blood flow in patients with stable CAD.

PATIENTS and METHODS

Study Population

We retrospectively reviewed the coronary angiography database of our Cardiology Department, Dokuz Eylul University, Faculty of Medicine Hospital, from 2008 to 2012. All patients with stable CAD who underwent direct stenting or stenting after balloon PTCA were recorded. Patients' medical and demographic data were collected from medical history records. All PCI procedures were performed by experienced interventional cardiologists. Stable CAD was defined as the presence of symptoms for several months in the absence of new onset or crescendo angina.

Official research permissions were obtained from the Local Ethics Committee of Dokuz Eylul University Faculty of Medicine.

All patients with stable CAD who had direct stenting and/or stenting after balloon PTCA to any native coronary artery between 2008 and 2012 were included in the study. We excluded patients who underwent coronary artery bypass operation, whose coronary angiography (CAG) and PCI records were not available, those with slow pre-procedural coronary blood flow, a history of acute MI, or thrombotic lesions in the target coronary artery, whose TFC could not be calculated, and those whose reference vessel diameter (RVD) was below 2.25 mm or above 3.75 mm. There were 55 patients (55 lesions) in the direct stenting group and 42 patients (43 lesions) in the stenting after balloon PTCA group.

TFC/ cTFC Calculation

All coronary angiograms were re-eveluated. Pre- and post-procedural TFC were calculated for each patient. Digital angiograms were evaluated by two independent cardiologists. Interobserver variability was calculated for angiographic evaluations obtained from 15 randomly selected patients and the result was assessed as different or same. This yielded an interobserver variability of ≤ 5%. Images obtained with different devices and with different number of frames were balanced to 30 frames per second (fps) speed, and measurements were made at 30 fps. TFC was calculated according to the method described by Gibson. The first and the last frames were defined as the moments at which all or at least 70% of the artery lumen was filled with antegrade flow and opaque contrast reached the distal end point of the artery, respectively. The frame difference between the two points was calculated as TFC. For the left anterior descending (LAD) artery, TFC was divided by 1.7 and corrected TFC (cTFC) was calculated[4]. The two groups were compared for pre- and post-procedural TFC and for TFC variations.

Statistical Analysis

Data were analyzed using the SPSS version 15.0 software. Parametric continuous variables were analyzed using the Student-t test and categorical variables with the Chi-square test. The Student-t test was used to compare pre- and post-procedural TFC between dependent groups. A P value of less than 0.05 was accepted as significant. Multivariate analysis was made with the dependent variable as TFC.

RESULTS

The average age in the direct stenting group was 60.4 years and was 62.3 years in the stenting after balloon PTCA group. Male patienst were more common in the direct stenting group (p= 0.02). Risk factors like diabetes mellitus (DM), hypertension, previous CAD and smoking were more common in the direct stenting group, and family history was more common in the stenting after balloon PTCA group. However, there were no statistically significant differences between the two groups with respect to risk factors (Table 1).

Overall, the target artery was the LAD in 54 patients, the right coronary artery (RCA) in 23 patients, and the left circumflex (LCx) artery in 18 patients. In three patients, the intervention was not targeted to major epicardial arteries, but to side branches (the diagonal branch of the LAD in two patients and the obtuse marginal branch of the LCx in one patient). When the two groups were compared, the number of the patients undergoing LAD and RCA interventions was greater in the direct stenting group, and the number of LCx interventions was greater in the stenting after balloon PTCA group (Table 2).

Concerning lesion types that were stented, there were no patients with a type C lesion in the stenting after balloon PTCA group versus five patients (9.1%) in the direct stenting group. Type A lesions were detected in six patients (10.9%) in the direct stenting group, and in three patients (7%) in the stenting after balloon PTCA group. The numbers of type B1 lesions were 37 (67.3%) and 32 (74.4%) in patients undergoing stenting

Table 1. Patients' demographics

	Direct stenting (n= 55)	Stenting after balloon PTCA	p
Age (year) mean ± SD, min-max	60.4 ± 10.3 (39-84)	62.3 ± 10.5 (40-81)	0.377
Diabetes mellitus	14 (% 25.5)	10 (% 23.3)	0.802
Gender (M/F) (%)	81.8/18.2	60.5/39.5	0.02
Hypertension n (%)	40 (%72.7)	27 (%64.3)	0.373
Smoking (%)	24 (%43.6)	19 (%44.2)	0.957
Hyperlipidemia n (%)	33 (%60.0)	19 (%44.2)	0.120
Family history n (%)	7 (%12.7)	11 (%25.6)	0.103
Previous CAD n (%)	29 (%52.7)	19 (%44.2)	0.401

* M/F: Male/female, CAD: Coronary artery disease, PTCA: Percutaneous transluminal coronary angioplasty.

Table 2. Distribution of stented coronary arteries

Stented vessel	Direct stenting (n= 55)	Stenting after balloon PTCA (n= 43)	p
LAD n (%)	32 (%58.2)	22 (%51.2)	0.022
LCx n (%)	5 (%9.1)	13 (%30.2)	
RCA n (%)	17 (%30.9)	6 (%14.0)	
Others (diagonal, obtus marginal, etc.) n (%)	1 (%1.8)	2 (%4.7)	

with and without balloon PTCA, respectively. Seven patients (12.7%) underwent direct stenting, and eight patients (18.6%) underwent stenting after balloon PTCA for type B2 lesions. No significant differences were found between the two groups with respect to the lesion types stented (p= 0.169).

The average lesion length was 15.2 mm in the direct stenting group compared to 15.3 mm in the stenting after balloon PTCA group (p= 0.883). The average reference vessel diameter (RVD) was significantly wider in the direct stenting group (2.9 mm vs. 2.7 mm; p= 0.001). Concerning stent types used, 23 patients (41.8%) received bare metal stents (BMS) in the direct stenting group, compared to 21 patients (48.8%) in the stenting after balloon PTCA group. The corresponding figures for drug-eluting stents (DES) were 32 (58.2%) and 22 (51.2%) in the two groups. No significant difference was found in implanted stent types (p= 0.488).

Pre- and Post-procedural TFC

The average pre-procedural TFCs showed no significant differences between the two groups (18.72 fps in the direct stenting and 18.13 fps in the stenting after balloon PTCA groups; p= 0.074). In both groups, the average TFCs decreased significantly after the intervention, with a 2.6 fps decrease to 16.12 fps in the direct stenting group and with a 1.5 fps decrease to 16.63 fps in the stenting after balloon PTCA group (p< 0.001). The decrease in TFC was significantly greater in the direct stenting than that found in the stenting after balloon PTCA group (p< 0.001). Overall, the post-procedural TFC decreased significantly from an average of 18.42 fps to 16.37 fps (by 2.05 fps, p< 0.001) (Table 3).

In multivariate analysis, which included procedure type, RVD, stented vessel type, age and gender, only the procedure type was found to have a significant and independent effect on TCF (p< 0.001) (Table 4).

DISCUSSION

The global increase in the prevalence of atherosclerotic CAD and innovations and developments in PCI techniques make PCI a more important and widespread procedure worldwide. Our retrospective study aimed to test whether direct stenting or stenting after balloon PTCA would result in better antegrade coronary blood flow in patients with stable CAD. Theoretically, as there is no balloon dilatation in direct stenting, this procedure is likely to cause less vascular damage, and thus to be associated with a decreased restenosis rate. Clinical and observational data

Table 3. post-Procedural decrease in TFC in the two treatment groups

	Direct stenting (n= 55)	Stenting after balloon PTCA (n= 43)	p
Decrease in post-procedural mean TFC mean ± SD, min-max	2.6 ± 1.43 (0-6) fps	1.5 ± 1.36 (0-4) fps	< 0.001

SD: Standart deviation; Fps: Frame per second; TFC: TIMI (thrombolysis in myocardial infarction) frame count; PTCA: Percutaneous transluminal coronary angioplasty.

Table 4. Multivariate analysis with the dependent variable as TFC

	Unstandardized Coefficients		Standardized Coefficients			95% confidence interval for B	
Model	**B**	**Std. Error**	**Beta**	**T**	**Sig.**	**Lower limit**	**Upper limit**
Fixed value	0.905	1.715		0.527	0.599	-2.502	4.312
Procedure type	1.287	0.311	0.426	4.143	0.000	0.670	1.904
Gender	0.426	0.342	0.127	1.243	0.217	-0.254	1.106
Age (years)	-0.004	0.014	-0.028	-0.288	0.774	-0.033	0.024
Vessel type	0.023	0.158	0.014	0.144	0.886	-0.291	0.337
Reference vessel diameter	-0.385	0.486	-0.081	-0.792	0.431	-1.350	0.580

* TFC: TIMI (thrombolysis in myocardial infarction) frame count.

have shown that less vascular damage is related with lower rates of restenosis[5,6]. Despite some studies showing no difference for major adverse cardiac events (MACE), it was shown that development of coronary dissections decreased significantly with direct stenting[7]. For this purpose, unlike previous studies, we used TFC and cTFC (for the LAD) for the evalution of antegrade coronary blood flow. There have been some studies in which TFC was used for the comparison of direct stenting and stenting after balloon PTCA in STEMI patients, but data are very limited for stable CAD. A study with STEMI patients showed significantly lower post-procedural TFCs with direct stenting, compared with stenting after balloon PTCA, which was related with better antegrade coronary blood flow[3]. In our study, we aimed to demonstrate this beneficial effect of direct stenting in stable CAD. Most studies that compared direct stenting with stenting after balloon PTCA were mainly concerned with the use of less opaque material, shorter fluoroscopy time and fewer catheters and assessed angiographic parameters like minimal lumen diameter and late lumen loss in the early phase, and stent restenosis in the late phase[1,8]. Additionally, we demonstrated a significantly greater decrease in post-procedural TFC with direct stenting compared to stenting after balloon PTCA, which indicates better microvascular circulation and antegrade coronary blood flow due to less peri-procedural microvascular dysfunction.

Studies comparing direct stenting and stenting after balloon PTCA generally include non-calcified type A and type B lesions. In our study, 9.2% of the lesions were type A, and 70% of the lesions were Type B1. Our study was similar to previous randomized studies in this respect[9,10]. Type C lesions were only found in 5% of the patients, and these patients were in the direct stenting group. Similar to other studies, lesions with an RVD below 2.25 mm or above 3.75 mm were excluded from the study. The size of the RVD was 2.9 mm in the direct stenting group and was 2.7 mm in the stenting after balloon PTCA group. The PREDICT study, which compared direct stenting and stenting after balloon PTCA by using minimal lumen diameter, late lumen loss and restenosis, reported the average RVD as 2.9 mm, similar to that of our study. In the DISCO study in which the RVD varied between 3 and 3.5 mm in 90% of the patients, there was a wider variation in the RVD when compared with our study. The average lesion length was 15.2 mm in the direct stenting group, and was 15.3 mm in the stenting after balloon PTCA group. This length was reported as 15 mm and 12 mm in the DISCO and PREDICT studies, respectively. In both radomized studies, similar to our study, the stented vessel was generally the LAD and common lesion types were type A and type B1 lesions [1,8].

In our study, except for male preponderance in the direct stenting group, demographic characteristics and risk factors were similar in the two groups. The average RVD was significantly wider in the direct stenting group than in the stenting after balloon PTCA group. A wider RVD could have a positive effect on TFC. Patients with type C lesions were also in the direct stenting group. Another difference was noted in the type of vessels stented. While the LAD and RCA were dominant in the direct stenting group, LCx was dominant in the stenting after balloon PTCA group. Stent types (DES and BMS) were similar in the two groups. In multivariate analysis, among other parameters, only the procedure type had a significant and independent effect on TFC.

In order to compare the effect of direct stenting and stenting after balloon PTCA on antegrade coronary blood flow, another method, fractional flow reserve (FFR), was also used in a small study. There were no differences between the two groups with respect to functional results and post-procedural increases in troponine I and creatine kinase MB [11]. Similarly, in the CK TEST trial which investigated post-procedural myocardial damage, increases in troponin I and creatine kinase MB were similar in the two groups[12]. TFC is an easy, repeatable and non-invasive method. Compared with other methods, it does not require additional costs and has a significant applicability and superiority. In TFC calculation, the most important factors are capture quality of coronary angiograms and timing of the filming. For an optimal TFC calculation, filming should be continued until the opaque reaches a fixed distal point. In practical circumstances, the operator may stop filming when he/she might think that enough information has been obtained, thus the procedure may be stopped before the opaque reaches the distal point. This constitutes the major difficulty in TFC calculation.

Limitations of The Study

The retrospective nature and relatively small size of the study may limit the applicability of our results to a wide CAD patient population. Distribution of the stented vessels differed between the two groups, with the LAD and RCA being dominant in the direct stenting group, and LCx being dominant in the stenting after balloon PTCA group. A wider RVD and a higher rate of male gender were foung in the direct stenting group. Nonetheless, the effect of these differences must have been largely lessened in multivariate analysis.

CONCLUSION

In stable CAD patients, both direct stenting and stenting after balloon PTCA techniques result in decreased TFC, which reflects improved coronary perfusion. This improvement is more remarkable in the direct stenting group, which is more likely to be associated with less peri-procedural microvascular damage and better microvascular circulation by direct stenting. Our results suggest that significantly decreased TFC can be placed on the list of advantages of direct stenting.

CONFLICT of INTEREST

The authors reported no conflict of interest related to this article.

AUTHORSHIP CONTRIBUTIONS

Concept/Design: ME, BA
Analysis/Interpretation: ME, ÖŞ, MAE, AA
Data acquisition: ME, FA, İK, BÜ, BK
Writing: ME, BA, ÖŞ
Critical revision: ME, AA, İK, BÜ, FA, MAE, BK
Final approval: All of authors

REFERENCES

1. Martinez-Elbal L, Ruiz-Nodar JM, Zueco J, López-Minguez JR, Moreu J, Calvo I, et al. Direct coronary stenting versus stenting with balloon pre-dilation: immediate and follow-up results of a multicentre, prospective, randomized study. The DISCO trial. Direct stenting of coronary arteries. Eur Heart J 2002;23:633-40.
2. Weber F, Schneider H, Warzok F, Petzsch M, von Knorre GH, Nienaber CA. Randomized comparison of direct and provisional stenting in de novo coronary artery lesions: the RADICAL study. Z Kardiol 2003;92:173-81.
3. Özdemir R, Sezgin AT, Barutcu I, Topal E, Güllü H, Açıkgöz N. Comparison of direct stenting versus conventional stent implantation on blood flow in patients with ST-segment elevation myocardial infarction. Angiology 2006;57:453-8.
4. Gibson CM, Cannon CP, Daley WL, Dodge JT Jr, Alexander B Jr, Marble SJ, et al. TIMI frame count: a quantitative method of assessing coronary artery flow. Circulation 1996;93:879-88.
5. Rogers C, Karnovsky MJ, Edelman ER. Inhibition of experimental neointimal hyperplasia and thrombosis depends on the type of vascular injury and the site of drug administration. Circulation 1993;88:1215-21.
6. Schwartz RS, Huber KC, Murphy JG, Edwards WD, Camrud AR, Vlietstra RE, et al. Restenosis and the proportional neointimal response to coronary artery injury: results in a porcine model. J Am Coll Cardiol 1992;19:267-74.
7. Alidoosti M, Salarifar M, Kassaian SE, Zeinali AM, Fathollahi MS, Dehkordi MR. In-hospital and mid-term adverse clinical outcomes of a direct stenting strategy versus stenting after predilatation for the treatment of coronary artery lesions. Cardiovasc J Afr 2008;19:297-302.
8. Baim DS, Flatley M, Caputo R, O'Shaughnessy C, Low R, Fanelli C, et al. Comparison of PRE-dilatation vs direct stenting in coronary treatment using the Medtronic AVE S670 Coronary Stent System (The PREDICT trial). Am J Cardiol 2001;88:1364-9.
9. Danzi GB, Capuano C, Fiocca L, Dallavalle F, Pirelli S, Mauri L, et al. Stent implantation without predilation in patients with a single, noncalcified coronary artery lesion. Am J Cardiol 1999;84:1250-3.
10. Le Breton H, Boschat J, Commeau P, Brunel P, Gilard M, Breut C, et al. Randomized comparison of coronary stenting with and without balloon predilatation in selected patients. Heart 2001;86:302-8.
11. Balachandran KP, Singh B, Sandilands A, Popusoi G, Rubino P, Baumbach A. Functional result following direct coronary artery stenting with drug eluting stents in chronic stable angina is similar to stenting after balloon predilatation. Int J Cardiol 2008;128:374-7.
12. Balducelli M, Varani E, Vecchi G, Paloscia L, Manari A, Santarelli A, et al. Direct coronary stenting versus stenting with balloon pre-dilation: incidence of enzyme release and follow-up results of a multicentre, prospective, randomized study. The CK and Troponin I Estimation in direct STenting (CK TEST) trial. Minerva Cardioangiol 2007;55:281-9.