Comparison of Different Stenting Techniques of Coronary Bifurcation Lesions: A Network Meta-Analysis of 7601 Patients

Type

Research paper

Keywords

crush, Coronary bifurcations lesions (CBL), DKcrush, culotte, T and protrusion (TAP). Provisional, Major adverse cardiovascular events (MACE)

Abstract

Introduction
Intervention on coronary bifurcations lesions (CBL) is challenging. While provisional side branch (PS) stenting is the recommended method in most cases, there is no consensus on the preferred 2-stent technique.

Material and methods
We performed a network meta-analysis including randomized controlled trials (RCT) and observational studies comparing stenting techniques in CBL with reported clinical outcomes. A mixed treatment comparison model generation was performed to compare culotte, T and protrusion (TAP), crush and provisional techniques.

Results
We included 14 RCT and 14 observational studies comprising 7,601 patients among whom 2,516 were treated with PS, 792 with TAP, 1,493 with culotte and 2,808 with crush. A Bayesian network meta-analysis showed a significant rate reduction of major adverse cardiovascular events (OR=0.73; 95%CI 0.52-0.99) and a trend for reduction in lesion revascularization (OR=0.72; 95%CI 0.48-1.11) and myocardial infarction (OR=0.62; 95%CI 0.3-1.08) with the crush technique, mainly driven by the double kissing (DK) crush, compared with all other stenting techniques. Other clinical outcomes, including mortality and stent thrombosis (ST) did not differ significantly between methods.

Conclusions
The crush technique, and especially DKcrush, is associated with improved outcomes compared to culotte, T and protrusion (TAP) and provisional techniques for CBL treatment. Further research is required to determine the optimal stenting technique for CBL.

Abstract

Background: Intervention on coronary bifurcations lesions (CBL) is challenging. While provisional side branch (PS) stenting is the recommended method in most cases, there is no consensus on the preferred 2-stent technique.

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Introduction

Coronary bifurcation lesions (CBL) account for 15-20% of all percutaneous coronary interventions (PCI) and constitute a major challenge for interventional cardiologists[1] in terms of both procedural success and long-term major adverse cardiac events (MACE)[2,3]. Based on data from multiple randomized controlled trials (RCT) and registries, current guidelines advocate the use of provisional side branch (SB) stenting for the majority of CBL[3]. However, an upfront double stent technique should be considered for complex CBL (long side branch lesions, difficult side branch access or high risk of side branch compromise) since a provisional strategy may potentially lead to acute or long-term occlusion of a significant side branch. In these cases, which account for 5 to 25% of CBL, a 2-stent technique may be needed for optimal results[3]. Several dual-stenting techniques are recommended, including reverse provisional stenting, T-stenting and small protrusion (TAP) in which a second stent is being advanced through the struts of the MB stent into the SB and deployed with slight (1-2mm) protrusion into the MB, then both the MB balloon ant the SB stent balloon are simultaneously inflated. Culotte technique in which 2 stents are deployed in tandem, from the main vessel into each branch with strut opening to each branch by kissing balloon inflation leaving the proximal main vessel covered with two overlapped stents, and crush modification including mini-crush and double kissing crush (DK crush) which consists of stenting from the main vessel into the SB, balloon crushing from the MB, stenting from the main vessel into the MB and final kissing balloon inflation. The DKcrush modification is performed with a 2 kissing balloon inflations, both prior and following the second stent deployment [3,4]. Nevertheless, due to the anatomical and technical complexity of these lesions and methods, treatment results may be affected by several factors such as the selected double stenting technique, operator's experience and the use of intracoronary imaging during the PCI[5,6]. Therefore, the optimal 2-stent technique for CBL remains controversial. Accordingly, we performed a network meta-analysis of RCT and observational studies comparing the clinical outcomes of various 2-stent techniques with provisional stenting in CBL.

Methods

The primary objective of this network meta-analysis was to compare the various 2 stents techniques for CBL, with a common comparator of a provisional technique, with regards to clinical outcomes including MACE defined in most studies as mortality, myocardial infarction and target vessel or lesion revascularization, target lesion revascularization (TLR), all-cause mortality, myocardial infarction (MI) and stent thrombosis (ST). Clinical outcomes and events rate are based on the definitions given and the reported incidents in each study. We included the recommended techniques such as crush, culotte, and TAP, but not simultaneous kissing stents which is no longer recommended (EBC statement). We included in the crush group all methods such as mini-crush, classic crush, and DK crush since the concept of the result was similar. Nevertheless, to assess the impact of DKcrush, we performed a separate analysis with DKcrush group as an independent group from other crush techniques. Two independent investigators (EK and LH) had systematically screened (January 2020) MEDLINE/PubMed for titles and abstracts containing the terms coronary bifurcation " OR " crush stenting" OR" provisional stenting" OR "culotte stenting", reviewed the full-text articles and determined their eligibility. Included in the meta-analysis were RCTs and observational studies, comparing at least two of the listed PCI techniques for CBL with available clinical follow-up separately for each technique. Studies with inadequate outcome data, duplication of data and those available only in abstract form were excluded from the analysis. Data was abstracted by additional two investigators (OB and AD) in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and Meta-analysis Of Observational Studies in Epidemiology (MOOSE) guidelines[7,8] The type of study, year of publication, time of follow up, treatment allocation and stenting technique, patients' age, gender, co-morbidities, left ventricular ejection fraction (LVEF) and outcome data for TLR, MACE, MI, ST and all-cause mortality at the longest available follow-up were extracted and recorded when available. We accepted the studies definitions for adverse events.

Statistical analysis

Dichotomous variables are expressed as percentages and continuous variables as mean ± standard deviation or median+ IQR (interquartile range) based on normal distribution. To compare directly and indirectly between the CBL interventional techniques: provisional, crash, culotte, and TAP we used a mixed treatment comparison model generation performed by GeMTC 0.14.3 software (GeMTC, http://drugis.org/software/r-packages/gemtc). Bayesian hierarchical random-effects model with directed acyclic graph model for general-purpose Markov chain Monte Carlo analysis was performed with 50,000 tuning iterations and 100,000 simulation iterations. Data is presented as odds ratios (OR) and 95% credible intervals (CrI). Convergence was appraised graphically according to Gelman and Rubin[9]. Data from a consistency model are presented, and the direction of findings were confirmed with an inconsistency model to serve as a sensitivity analysis. Additional sensitivity analysis was performed with removal of one study at a time to confirm directionality and magnitude of findings. Statistical significance was defined as a P-value <0.05.

Results

We screened and reviewed a total of 4,005 MEDLINE citations using the previously defined search terms. 212 abstracts which met the inclusion/exclusion criteria were evaluated, and from them 76 full-text publications were reviewed in detail. Finally, we entered 28 studies in the meta-analysis, including 14 RCTs [10,11,20–23,12–19] and 14 observational studies [24,25,34–37,26–33]. The study flow chart is shown in **Figure 1**.

Characteristics of studies included in the meta-analysis are presented in **Table 1**. Among the 7,601 patients with CBL identified from the included articles, 1,493 were treated with culotte, 2,808 with crush, 792 with TAP and 2,516 with provisional stenting. **Figure 2** represents the number of patients treated by each BCL technique. Mean follow-up was 28.6 months. Patients baseline characteristics are shown in **Table 2**. Mean age was 65.9± 9.9 years. Men comprised 76.3% of the population, 33% were smokers and 28% had diabetes mellitus. Prior MI was present in 24%, 28% of patients had undergone previous PCI and 4.8% had prior coronary artery bypass graft (CABG) surgery. The mean left ventricular ejection fraction (LVEF) was 54.5± 12%. Angiographic and procedural characteristics are shown in **Table 3**. True bifurcation lesions were present in over 90% of the patients, left main lesions were included in 18 studies and were recorded in 3,108 patients, kissing balloon inflation

(KBI) was performed in 81% of CBL and intracoronary imaging was used in 13 studies and 2,011 patients.

The network plot for MACE with and without DKcrush is presented in **figure 3**. The Bayesian network meta-analysis demonstrated the superiority of the crush technique, but not culotte and TAP, over provisional stenting in reduction of MACE (OR=0.73; 95%CI 0.52-0.99) (**Figure 4**). This was mostly driven by lower TLR and MI rates, while mortality and ST did not differ significantly between stenting methods, possibly due to the low event rate and lack of statistical power.

Rankings of therapies according to the probability of being the best, second, third and fourth based on the Bayesian network meta-analysis revealed similar results with the crush technique as a leading 2-stent treatment modality in all outcomes, as shown in **Figure 5**

When differentiating between double kissing crush (DKcrush) and other crush methods, the results indicate that the crush superiority was driven by the DKcrush technique (**Figure 6**). Ranking of treatment showed similar findings indicating that it is DKcrush which results in improved clinical outcome for patients with bifurcation lesions requiring 2 stents (**figure 7**).

When limiting the analysis to RCTs, there was no statistically significant difference in any of the stated endpoints between provisional stenting and the various 2 stent techniques, although there was a trend favoring the crush technique over provisional stenting in terms of TLR (**supplementary figures 1-4**). Similar results were found when analyzing only studies of left main bifurcation disease, with a trend for superiority of the crush technique over other 2 stent techniques, especially over culotte in terms of TLR and MACE (**supplementary figures 5-8**). When excluding a single study at a time there was not significant difference in the results.

Discussion

The main finding of the largest meta-analysis so far of separately grouped CBL stenting techniques, is that the crush technique provides superior clinical outcomes as compared to any other technique in the treatment of CBL. This superiority in terms of MACE is driven mostly by lower rates of TLR and MI and by use of the DKcrush method. Our finding is supported by the similar results observed in various analyses, including only left main studies or RCTs. There were no significant differences between techniques in terms of mortality and stent thrombosis. The impact of the method used may have been less pronounced for these clinical outcomes due to low event rates and lack of statistical power.

The main drawback of the crush technique and in particular DKcrush, is the commitment to 2 stents deployment. Therefore, this approach cannot be used as a bail-out for provisional stenting, in contrast to the culotte and TAP techniques. According to our results crush technique with the preference for DKcrush is to be used mainly in cases where 2 stents are needed upfront, such as the presence of a severe long lesion in the SB, as suggested by the European Bifurcation Club consensus document[38].

Extensive published data exist regarding the optimal technique for CBL. However, besides the general recommendation for provisional stenting that was shown to be superior to 2-stent techniques[39], up until recently there were no recommendations regarding which 2-stent technique should be employed. The

DKCRUSH trials showed superiority of this technique over culotte and classic crush technique[40] and even provisional stenting[13,15,41]. This can result from facilitating easier SB access and higher rate of KBI, which subsequently preserves the carina covering by improved SB and MB stents apposition and reduces stent malformation at the bifurcation[42] . A recently published network meta-analysis by Di-Gioia et al including only RCTs showed similar results to our findings[43]. However, this meta-analysis included several trials which combined several two stenting techniques into a single group, comprising almost 1,500 patients. A third of the crush stenting group in the British Bifurcation Coronary study[44] included patients who underwent other techniques and in the Nordic Bifurcation Study[45] it was half of the crush group. Likewise, the culotte group in the Nordic Bifurcation Study IV[46] included 35% of patients with different techniques. In the present analysis, the largest one so far, we included only reported data on individual stenting techniques in RCT's along with observational trials for the main analysis along with a sensitivity analysis for RCTs only.

Many additional factors may impact patient outcome following CBL stenting other than the technique used, including clinical, demographic, anatomical and physiological features, as well as adjunctive procedural techniques, operator experience and adjunctive pharmacotherapy.

It has been previously shown that risk scores[47] and comorbidities such as diabetes[48] increase the risk of adverse events in patients with CBL treated percutaneously. The Medina classification and involvement of the SB[49–52] are important predictors of procedural success and long-term adverse events, but are on occasion difficult to assess due to the subjectivity of visual assessment and the complexity of the three dimensional anatomy depicted on a two dimensional screen[53].

Intracoronary imaging can clarify lesion characteristics and has been shown to improve clinical outcome of patients undergoing PCI[54,55], however, its utilization rate and methods varies significantly from current recommendations[56,57]. Arguably, the most important issue in treating bifurcation lesions is operator's proficiency. Experienced operators were shown to achieve better outcomes than less experienced ones when performing PCI of the LM, the most important coronary bifurcation[58]. Hence, it could be that operator preference and familiarity with each technique is the most important determinant of outcome, possibly even more than the technique itself. Therefore, when choosing the appropriate stenting technique in CBL, all of the above parameters should be taken into consideration, including utilization of correct work projections that clarify the CBL, use of advanced physiological and imaging tools such as pressure wires and intravascular imaging and operator skill with the various techniques in different clinical scenarios. In addition, the development of dedicated CBL stents with various mechanisms may further improve the treatment of these lesions[59–61].

Our study has several limitations. First, the meta-analysis includes both RCTs and observational studies, which may have selection biases as there could be additional confounders that could impact the results and were not necessarily reported. Nonetheless, a sensitivity analysis including only randomized controlled trials showed an overall similar result in all outcomes. Second, the bifurcation classification and lesion complexity vary from study to study and are not necessarily adjudicated, especially considering the low usage rate of intracoronary imaging. Third, the reported outcome definitions vary between studies and therefor impact the total event rate with each technique.

In conclusion, our study demonstrates that among the various 2-stent techniques, crush might be associated with potentially better outcomes compared with culotte and TAP, mostly driven by the reduction of MACE with the DKcrush method. Further research should clarify the role of potential factors, such as intracoronary imaging and physiology and operator's experience, that may impact the procedural success and long-term outcome with the various techniques.

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Figure 1. Flow chart showing the process of selecting studies to the meta-analysis.

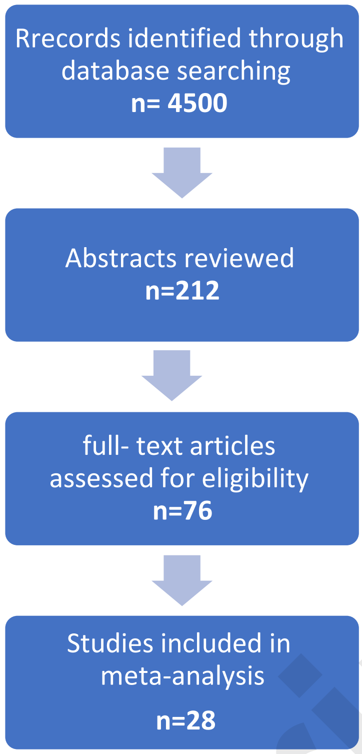

Figure 3. Network diagram with (A) and without (B) combining double-kissing crush technique with other crush techniques.

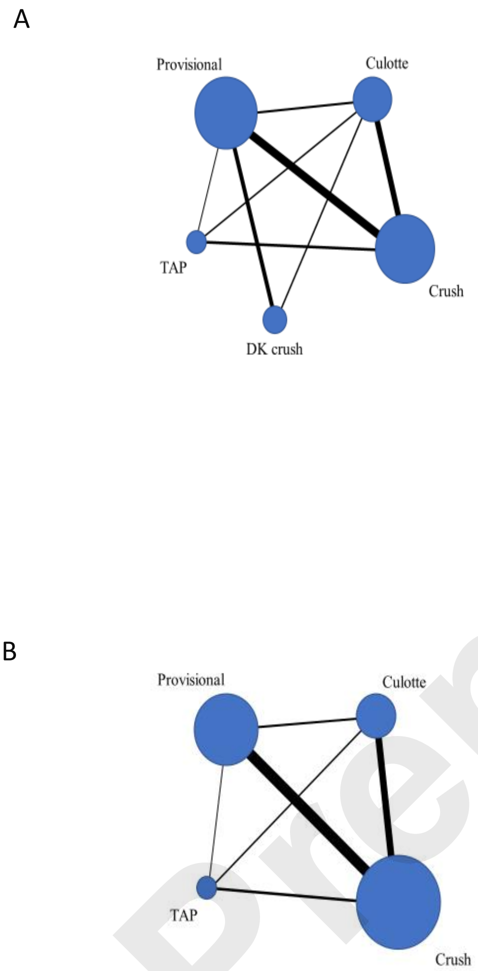

Figure 2. Representativeness of each bifurcation stenting technique in the included studies.

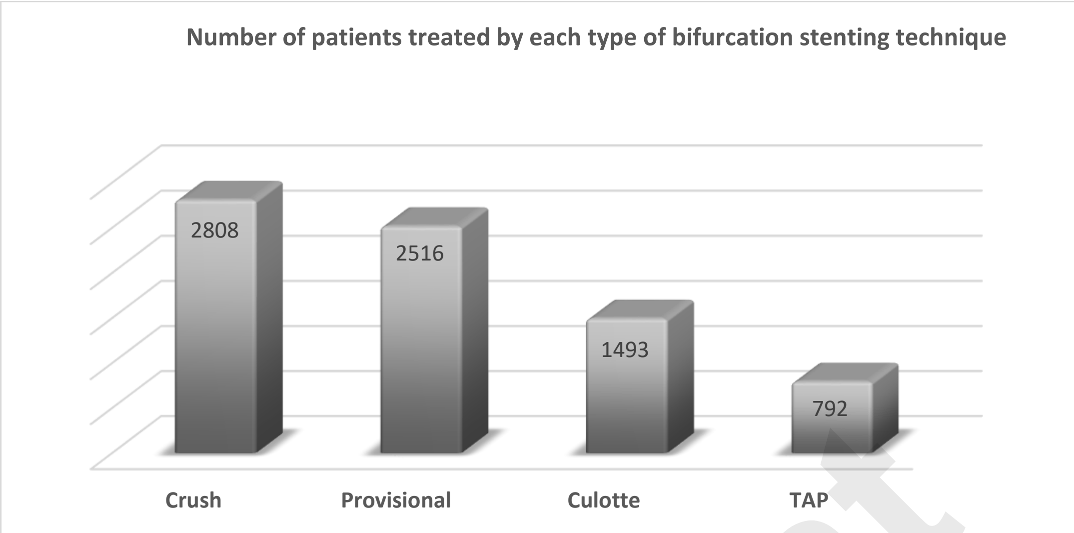

Table 1. Study characteristics.

Study	Left Main	Year of publication	Follow-up time	Design	Cohort size	Groups (n)
BBK II[10]	both	2016	12	RCT	300	TAP 150 culotte 150
BBK I[11]	non LM	2015	60	RCT	202	TAP 101 Provisional 101
CACTUS[16]	non LM	2008	6	RCT	350	Crash 177 Provisional 173
DKCRUSH II[17]	both	2017	60	RCT	366	Crush 183 Provisional 183
DKCRUSH III[18]	LM	2015	36	RCT	419	Crush 210 Culotte 209
DKCRUSH V[34]	LM	2019	36	RCT	482	Crush 240 Provisional 242
EBC II[20]	Non LM	2016	12	RCT	200	Culotte 97 Provisional 103
Kim[21]	Non LM	2015	12	RCT	419	Crush 213 Provisional 206
Nordic II[22]	Both	2013	36	RCT	424	Crush 209 Culotte 215
Pan[23]	Non LM	2004	6	RCT	91	TAP 44 Provisional 47
Ruiz-Salmeron[12]	Non LM	2013	9	RCT	69	TAP 36 Provisional 33
Zheng[13]	Both	2016	12	RCT	300	Crush 150 Culotte 150
Zhang[14]	Both	2016	9	RCT	104	Culotte 52 Provisional 52
Ye[15]	Both	2012	12	RCT	68	Crush 38 Provisional 30
Chen LM[24]	LM	2012	60	observational	387	Crush 155 Provisional 232
FAILS 2[25]	LM	2018	31	observational	237	Crush 103 TAP 66 Culotte 68
Fan PSM[26]	Both	2016	12	observational	132	Culotte 66 Provisional 66
Freixa[27]	Both	2013	49.2	observational	360	Crush 304 culotte 56
Galassi[28]	Non LM	2009	36	observational	457	Crush 199 Provisional 258
Ge[29]	Non LM	2006	12	observational	182	Crush 121 TAP 61
GISE SICI[30]	LM	2008	24	observational	705	Provisional 456 Crush 121 TAP 128
Kanei[31]	LM	2010	22	observational	106	Crush 64 TAP 42
Kaplan[32]	Non LM	2007	9	observational	80	Culotte 45 TAP 35
Migliorini[33]	LM	2017	12	observational	405	Crush 127 provisional 278
MITO[34]	LM	2016	60	observational	225	Crush 135 Culotte 90
Uchida[59]	Non LM	2009	8±4	observational	92	Provisional 33 Crush 59
Ohya[60]	Non LM	2018	24	observational	356	Culotte 295 TAP 69
Colombo[61]	Non LM	2004	6	observational*	83	Provisional 23 TAP 60

LM=left main

* Statistical analysis was performed as treated and not intention to treat (ITT)

Table 2. Patients demographics and comorbidities.

Study	Age (mean± SD)	Male (%)	Ejection fraction (mean± SD)	Diabetes (%)	Smoking (%)	Hypertension (%)	Dyslipidemia (%)	CABG (%)	PCI (%)	MI (%)
BBK II	67.7 ± 10.5	73.7	56.5± 6.9	27.7	11.3	86.7	11.3	6.3	35	18.7
BBK I	66.8 ±9.9	78.8	60± 12	22.25	11.9	90.6	NA	3.5	48	19.8
CACTUS	66 ± 10	78.3	56± 8.5	22.9	18.6	75.1	67.1	5.1	28.9	40
DKCRUSH II	64.3 ± 10.6	77.3	NA	21.3	NA	63.1	31.4	0.3	21	15.8
DKCRUSH III	63.8 ± 9.8	78.5	58.7± 11	31	26.7	65.9	41.8	NA	18.6	14.6
DKCRUSH V	64.5+9.5	80.3	59.5± 9	27.2	33.2	68.7	47.5	0.8	15.8	21.4
EBC 2	63.2 ± 11.5	81.5	NA	28	53	65.5	70	NA	40.5	40
Kim	61± 8.8	75.2	59.9± 7	27.4	28.9	55.4	59.7	NA	7.4	4.3
Nordic II	65 ±10.5	71	57± 11.5	13.9	23.6	61.1	79	4.5	36.8	NA
Pan	59.6 ± 10.5	79	57.6± 11	40.7	45.1	58.2	47.3	NA	NA	28.6
Ruiz-Salmeron	63.6 ± 12.9	81	NA	39	55	70	58	3.0	23	NA
Zheng	63.5 ± 8.5	73.4	23.6± 9.2	23.4	41.7	71.7	73	NA	24.7	NA
Zhang	64.35 ± 9.1	20.2	NA	20.2	55.8	65.4	11.5	NA	24.4	21.2
Ye	62.7± 10	69.1	62.8±8.2	16.8	NA	72.1	19.1	NA	NA	8.8
Chen LM	66.8 ±10	78.8	NA	28.7	32	73.4	52.7	NA	35.6	17.6
FAILS 2	71 ± 10.9	77	54.6±11.7	33	33.2	80	65.8	6.1	46.5	29.2
Fan PSM	64.1 ± 9.6	80.3	NA	34.1	47	56.8	37.9	0.7	12.9	25.8
Freixa	63.3 ± 11.7	73.6	NA	26.7	52.5	63.6	76.1	9.4	21.7	NA
Galassi	63.4 ± 10.1	77.9	50.2± 9.8	32.2	56.9	61	60	5.5	NA	31.73
Ge	62 ± 11	88.5	52.4± 8.5	24.7	51.6	63.7	69.2	18.1	NA	40.7
GISE SICI	*71.3 (32.3-94.1)	73.6	54± (20-80)	28.9	36.2	68	63.4	NA	NA	NA
Kanei	63.2 ± 12.4	57.5	53.2±12	30.2	24.5	72.6	60.4	2.8	NA	14.15
Kaplan	66.4 ± 11.3	78.8	55.6± 10	28	41.3	68	69.3	5.2	27.3	49.3
Migliorini	71 ± 10.5	80	NA	25.2	NA	68	56	NA	NA	22
MITO	68.9 ± 10.3	79.6	57± 8.7	34.2	16	80.4	74.2	NA	56.4	30.7
Uchida	67.5±18.76	84.78	60.1	48.91	9.78	47.83	57.61	6.52	NA	28.26
Ohya	70.7±10.4	80	NA	43	16	78	67	3	38	34
Colombo	62.7 ±11	80.23	59.3±11	22.11	NA	NA	NA	NA	NA	NA

*reported median and inter quartile range (IQR)

CABG = coronary artery bypass graft, PCI = percutaneous coronary interventions, MI = myocardial infarction

Table 3. Angiographic and procedural characteristics.

Study	Stent diameter-MB (mm)	Stent diameter -SB (mm)	Main vessel length of stent (mm)	Side branch length of stent (mm)	True bifurcation (%)	Use of final kissing balloon dilatation (%)	Use of IVUS / OCT (%)
BBK II	NA	NA	NA	NA	97	100	NA
BBK I	3.2± 0.48	2.14± 0.45	NA	NA	68	100	NA
CACTUS	NA	NA	23.± 50.8	18± 5.6	94	91.1	IVUS MB 3.7 SB 2.6
DKCRUSH II	NA	NA	28.7± 13	16.5± 8.8	100	89.3	IVUS 47.3
DKCRUSH III	3.37±0.37	3.03± 0.41	34.6± 15.03	26.3± 12.9	100	99.5	IVUS 71.4
DKCRUSH V	3.26± 0.37	2.94±0.4	48.7± 18.5	30.4± 9.8	100	89.2	IVUS 41.7
EBC 2	3.04±0.32	2.66±0.3	23.2± 4.95	20.3± 6.2	100	95.1	NA
Kim	3.3±0.3	2.7±0.2	37.1±15.1	21.4±6.8	87	87.6	IVUS MB 95.7 SB 85.7
Nordic II	NA	NA	23.6± 9.2	10.6± 5.7	78	88.5	NA
Pan	2.9 ±03	2.5± 0.3	25.5± 10.7	NA	100	68	NA
Ruiz-Salmeron	NA	NA	24± 11	NA	87	54	NA
Zheng	NA	NA	23.7± 7.1	10.3± 5.7	100	78.7	NA
Zhang	NA	NA	NA	NA	100	43.8	NA
Ye	3.12± 0.36	2.69± 0.33	32.26± 14.1	19.5±7.8	100	94.1	NA
Chen LM	3.38± 0.41		29.2± 13.5	NA	95	62	IVUS 16.3
FAILS 2	3.8±0.4	3.2±0.6	22.3± 6.5	19.3± 5.8	91	90.3	IVUS 24.6 OCT 3.7
Fan PSM	3.0±0.39	2.74±0.3	36.4± 15.8	20.4±9.5	100	94.7	IVUS 9.1
Freixa	NA	NA	NA	NA	90	82.5	NA
Galassi	2.87±0.37	2.54±0.3	29.6± 13.4	18.4± 7.5	96	79.8	NA
Ge	NA	NA	28.9± 11.5	23.2± 9.3	NA	63.4	NA
GISE SICI	NA	NA	NA	NA	NA	42.3	NA
Kanei	3.0± 0.3	2.7±0.3	18.2± 6.3	12.5± 4.8	77	16	NA
Kaplan	2.93±0.35	2.57±0.3	20.8± 6	16.6 ±5.9	53	85	NA
Migliorini	3.9 ± 0.25	NA	31 ± 10.1	NA	50	82	IVUS 70
MITO	3.4±0.2	3.1±0.3	23.8± 6	20.8± 6.1	89	98.2	IVUS 67.6 OCT 8.9
Uchida	3±0.68	2.62±0.64	26.6±15.8	19.8±11.4	75	98	IVUS 71
Ohya	NA	NA	25.6±12.2	17.8± 9.1	98	100	IVUS 58
Colombo	NA	NA	NA	NA	100	88.23	IVUS 100

MB = main branch, SB = side branch, IVUS = intravascular ultrasound, OCT = optical coherence tomography

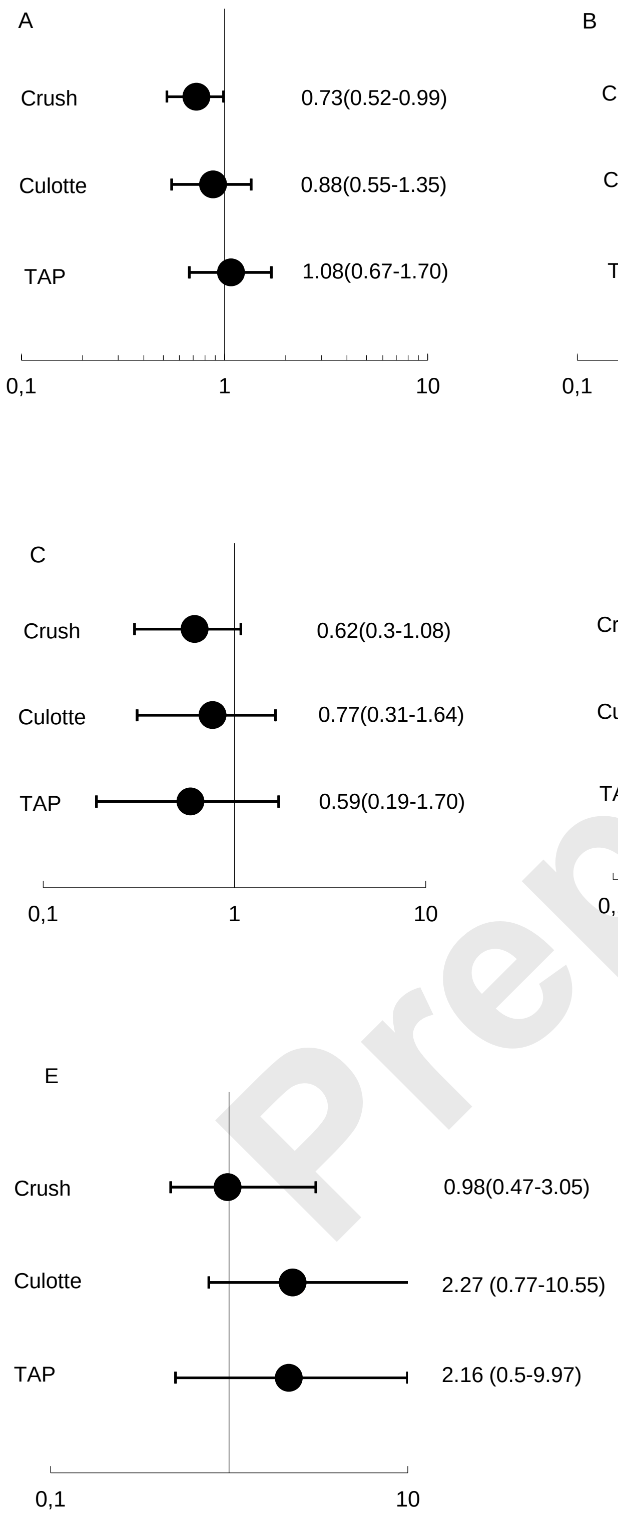

Figure 4. Forest plots of: (A) major adverse cardiac events, (B) target lesion revascularization, (C) myocardial infarction (D) all-cause mortality, and (E) stent thrombosis and between Crush, culotte and TAP techniques compared to provisional technique.

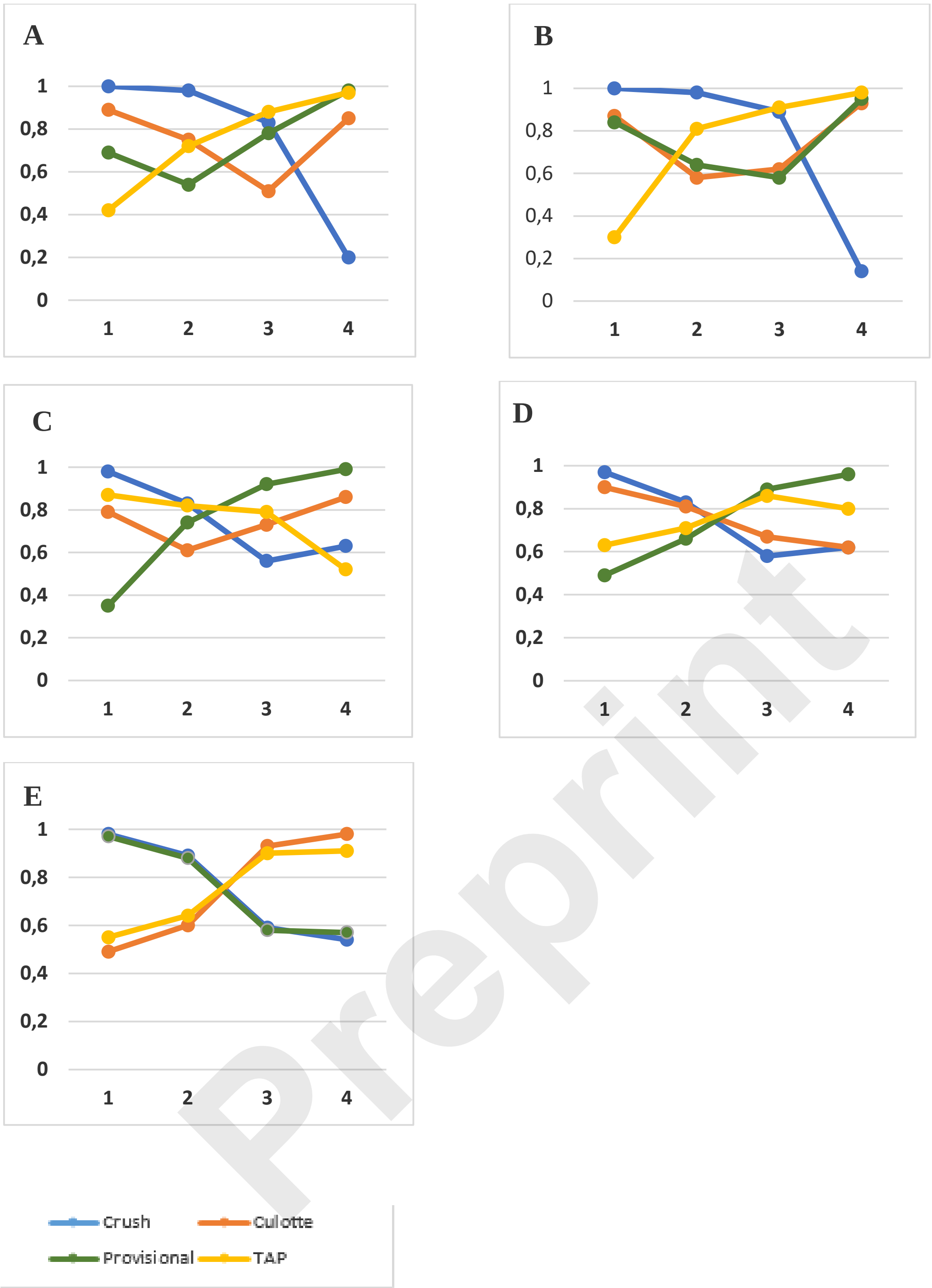

Figure 5. Ranking chart for the probability of the best, second, third and fourth treatment for: (A) major adverse cardiac events, (B) target lesion revascularization, (C) myocardial infarction (D) all-cause mortality, and (E) stent thrombosis and between Crush, culotte and TAP techniques compared to provisional technique.

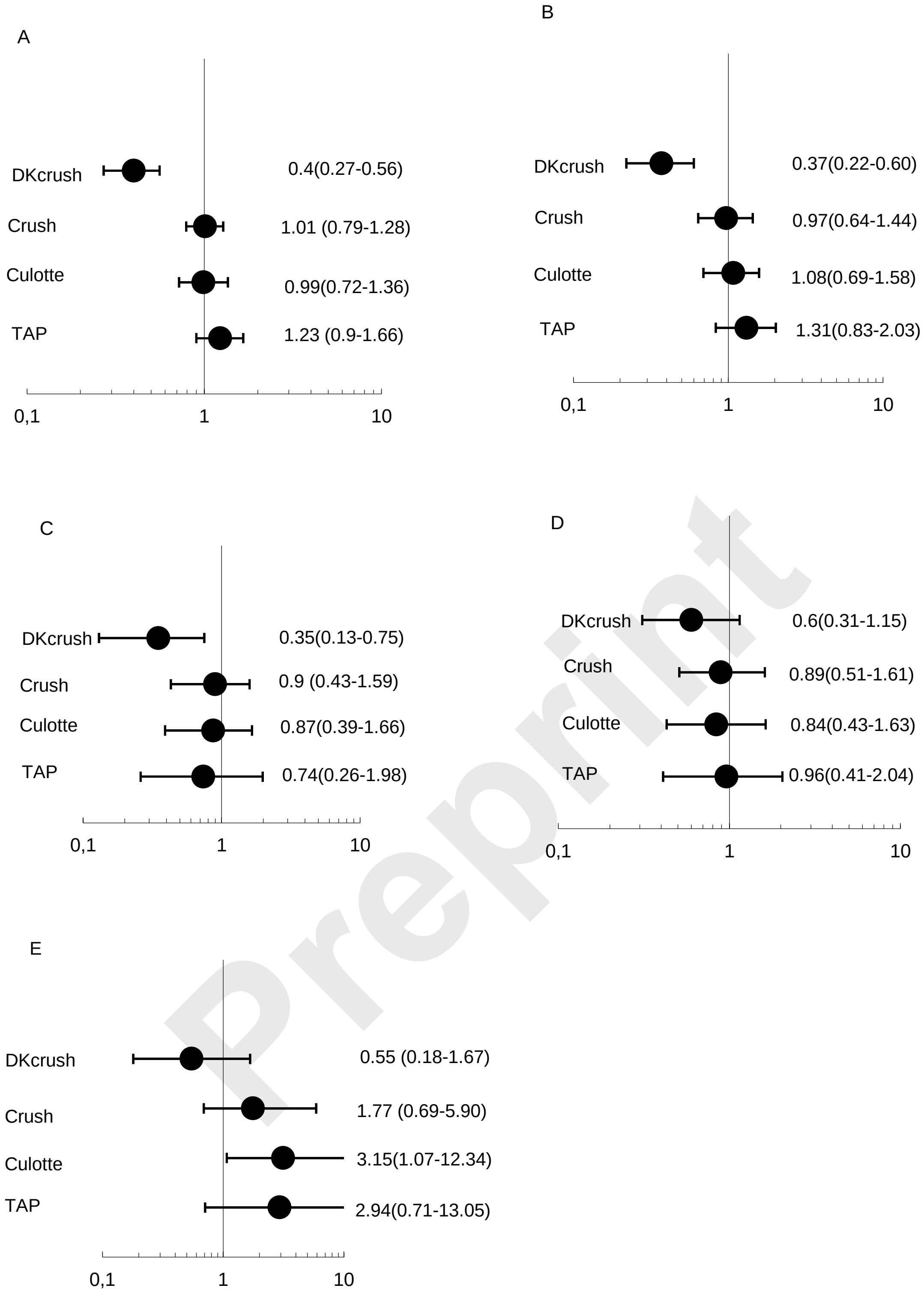

Figure 6. Forest plots of: (A) major adverse cardiac events, (B) target lesion revascularization, (C) myocardial infarction (D) all-cause mortality, and (E) stent thrombosis and between DKcrush, crush, culotte and TAP techniques compared to provisional technique.

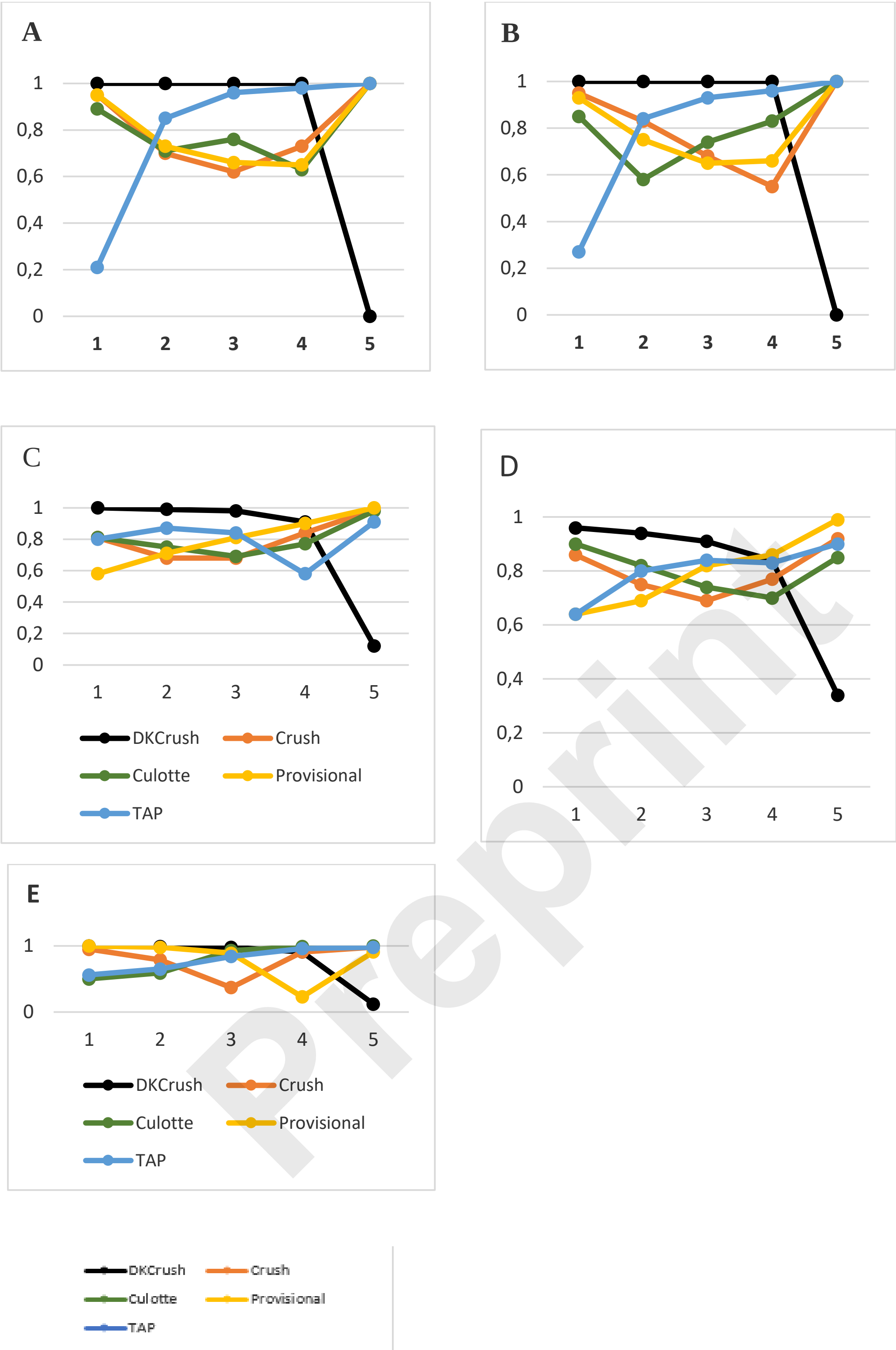

Figure 7. Ranking chart for the probability of best, second, third and fourth treatment for: (A) major adverse cardiac events, (B) target lesion revascularization, (C) myocardial infarction (D) all-cause mortality, and (E) stent thrombosis and between DKcrush, crush, culotte and TAP techniques compared to provisional technique.

Supplementary graphs

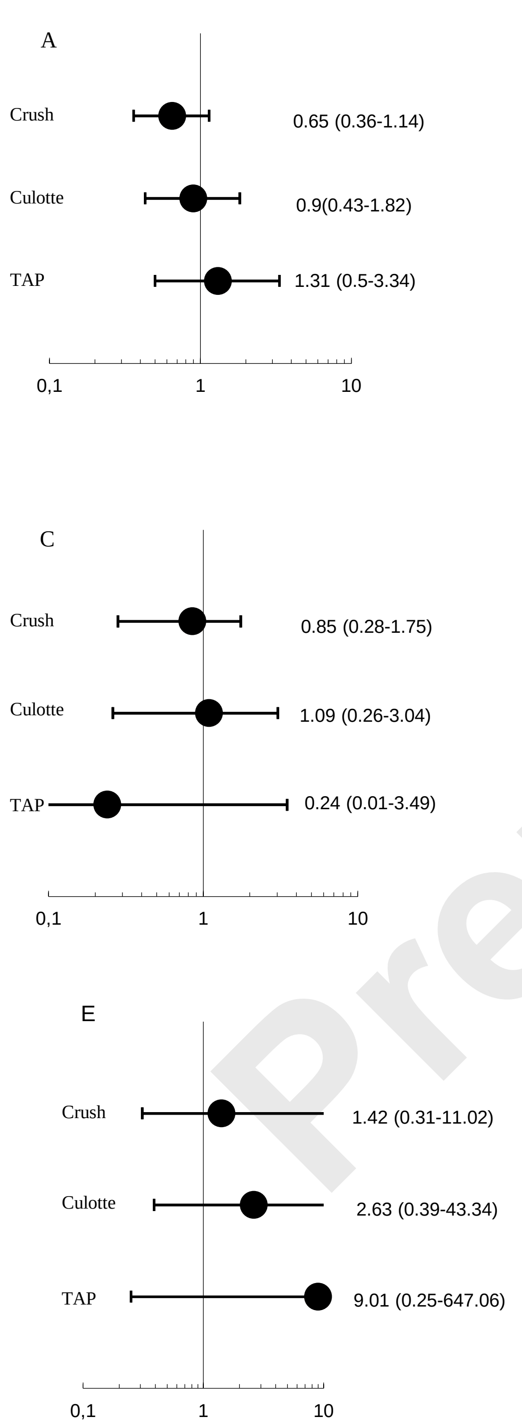

Figure 1. Forest plots of: (A) major adverse cardiac events, (B) target lesion revascularization, (C) myocardial infarction (D) all-cause mortality, and (E) stent thrombosis and between crush, culotte and TAP techniques compared to provisional technique in randomized controlled studies.

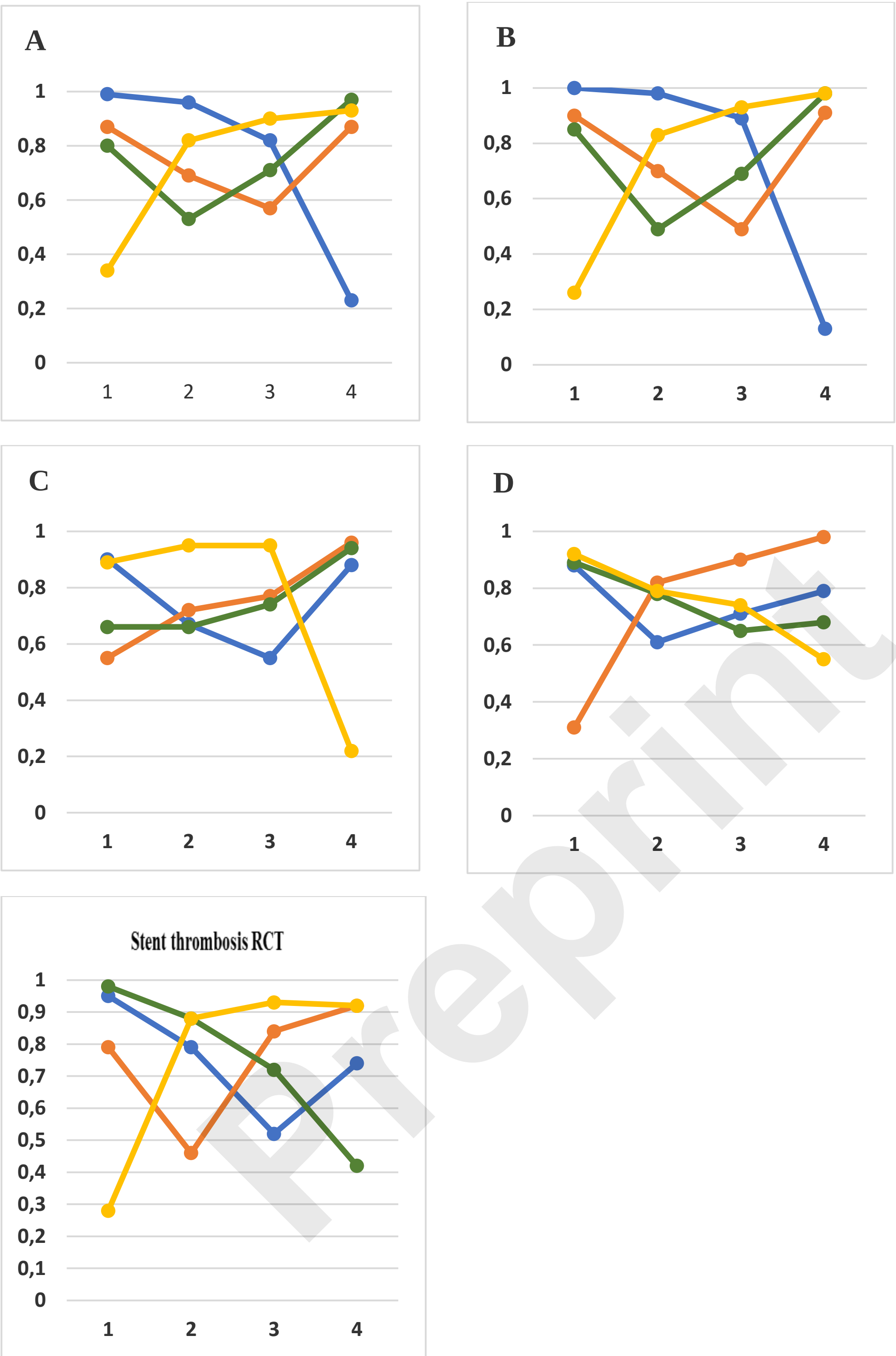

Figure 2. Ranking chart for the probability of best, second, third and fourth treatment for: (A) major adverse cardiac events, (B) target lesion revascularization, (C) myocardial infarction (D) all-cause mortality, and (E) stent thrombosis and between crush, culotte and TAP techniques compared to provisional technique in randomized controlled studies.

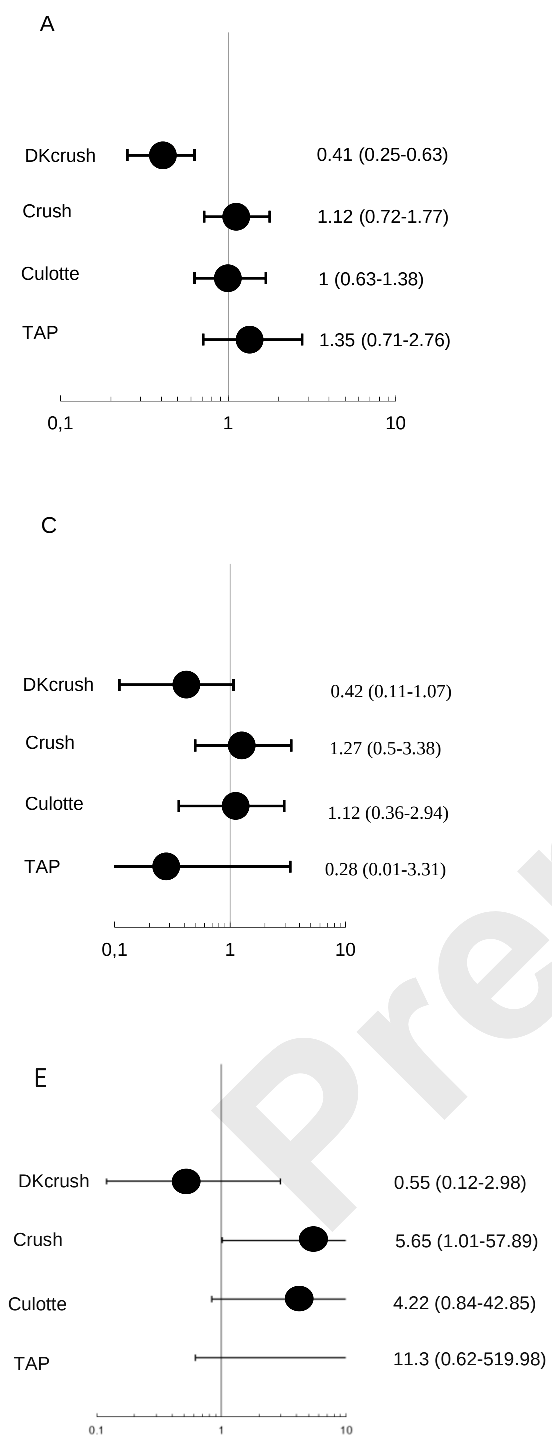

Figure 3. Forest plots of: (A) major adverse cardiac events, (B) target lesion revascularization, (C) myocardial infarction (D) all-cause mortality, and (E) stent thrombosis and between DKcrush, crush, culotte and TAP techniques compared to provisional technique in randomized controlled trials.

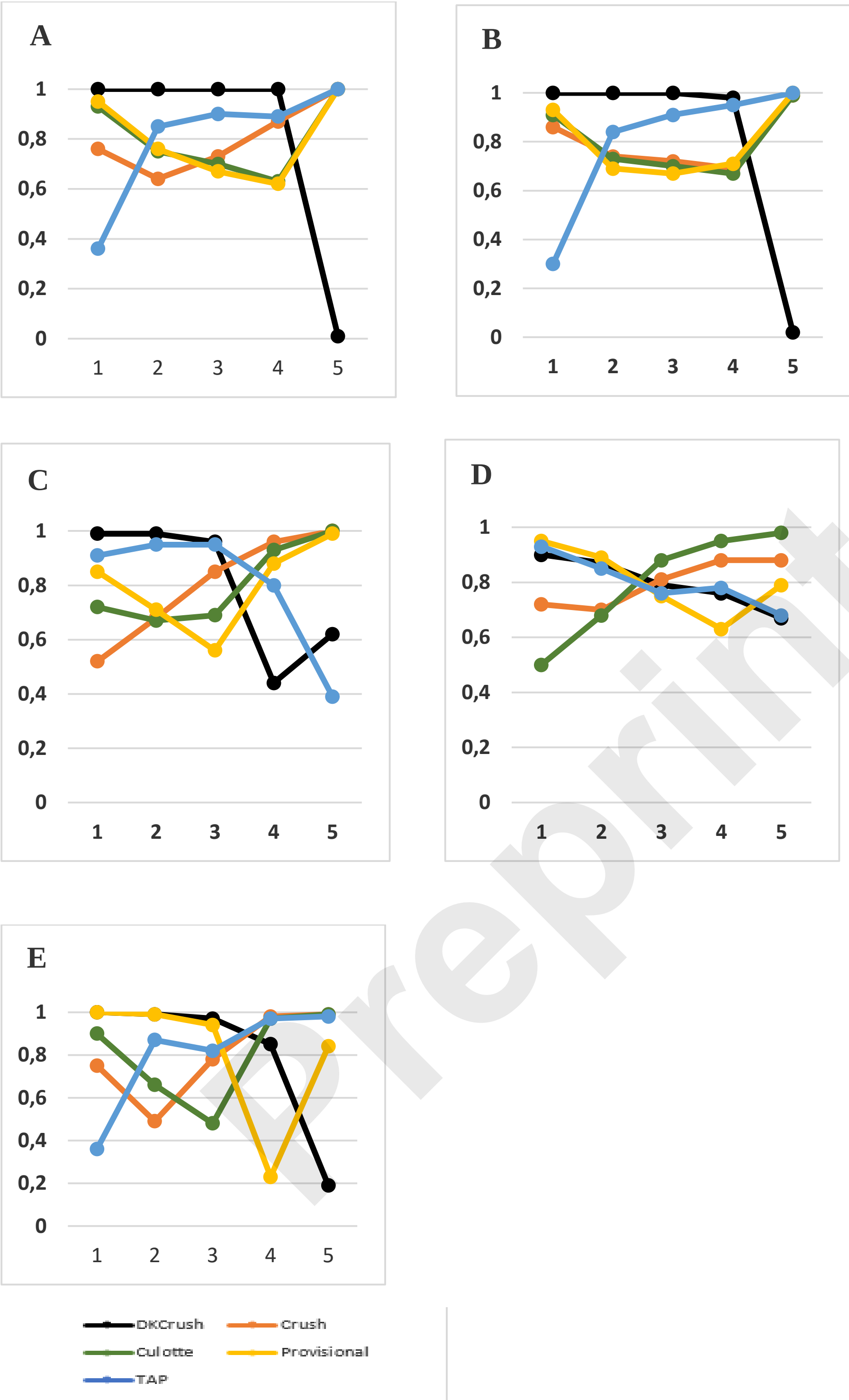

Figure 4. Ranking chart for the probability of best, second, third and fourth treatment for: (A) major adverse cardiac events, (B) target lesion revascularization, (C) myocardial infarction (D) all-cause mortality, and (E) stent thrombosis and between DKcrush, crush, culotte and TAP techniques compared to provisional technique in randomized controlled trials.

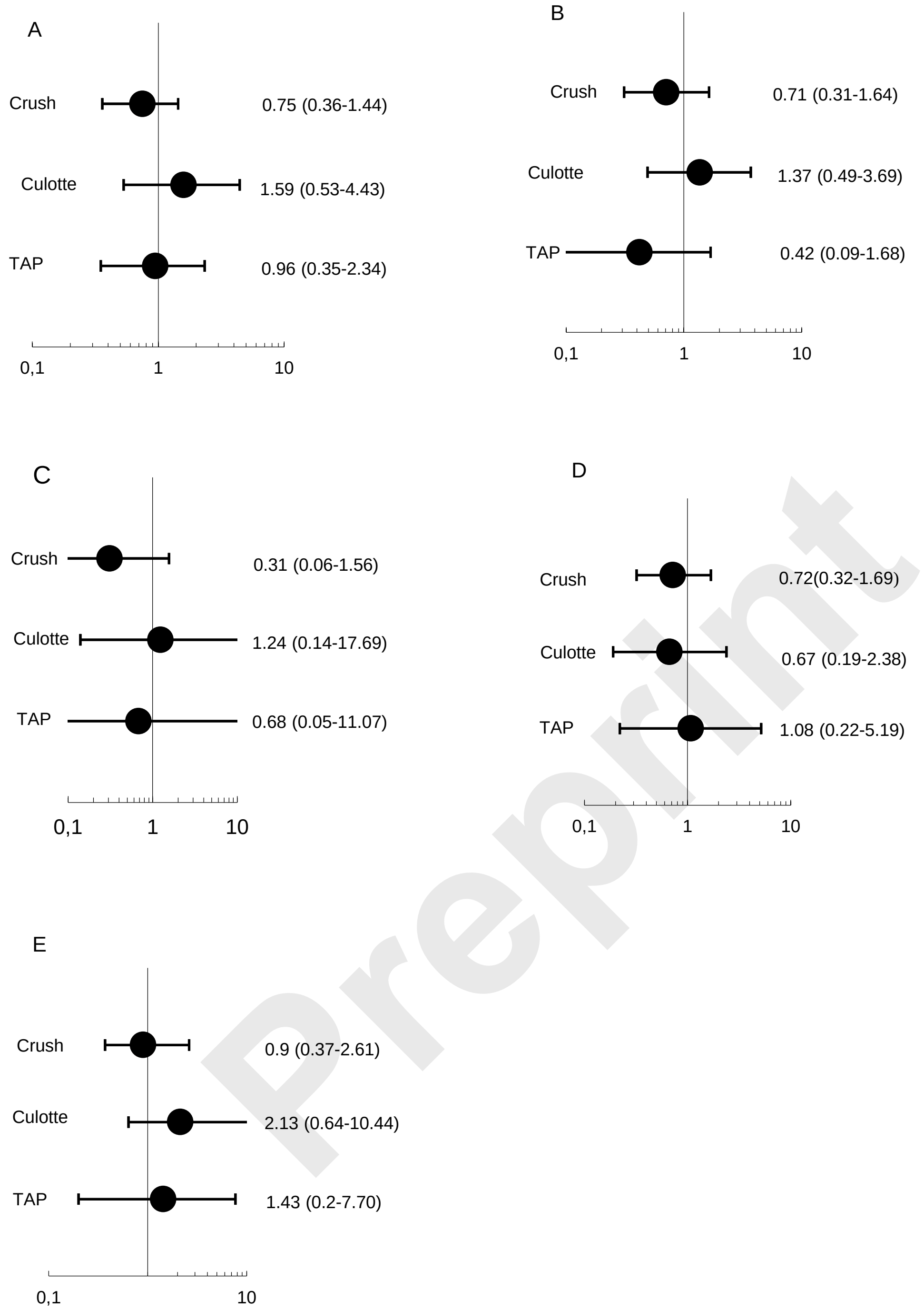

Figure 5. Forest plots of: (A) major adverse cardiac events, (B) target lesion revascularization, (C) myocardial infarction (D) all-cause mortality, and (E) stent thrombosis and between Crush, culotte and TAP techniques compared to provisional technique in treatment of left main disease.

Figure 6. Ranking chart for the probability of best, second, third and fourth treatment for: (A) major adverse cardiac events, (B) target lesion revascularization, (C) myocardial infarction (D) all-cause mortality, and (E) stent thrombosis and between Crush, culotte and TAP techniques compared to provisional technique in treatment of left main disease.

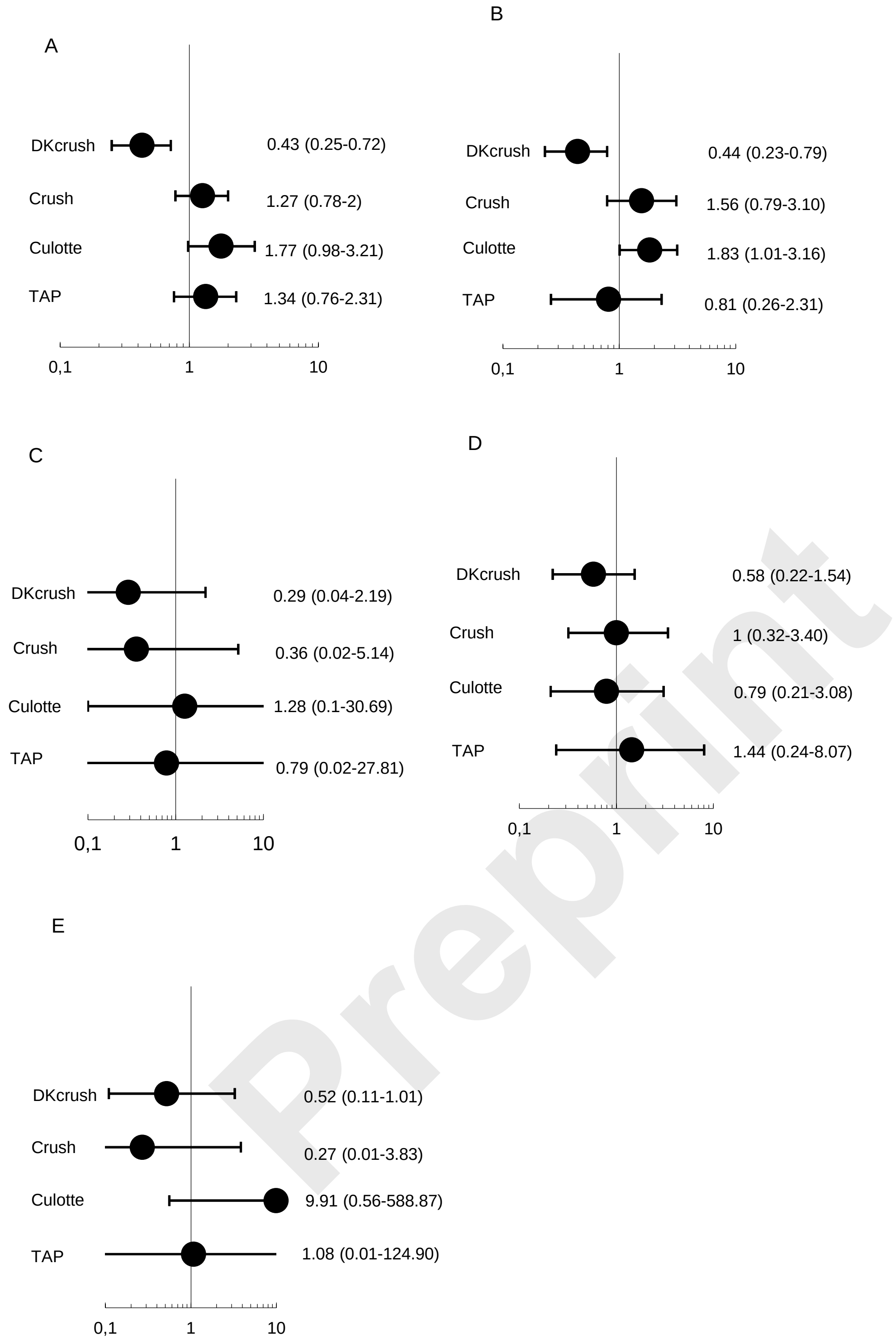

Figure 7. Forest plots of: (A) major adverse cardiac events, (B) target lesion revascularization, (C) myocardial infarction (D) all-cause mortality, and (E) stent thrombosis and between DKcrush, crush, culotte and TAP techniques compered to Provisional technique in treatment of left main disease.

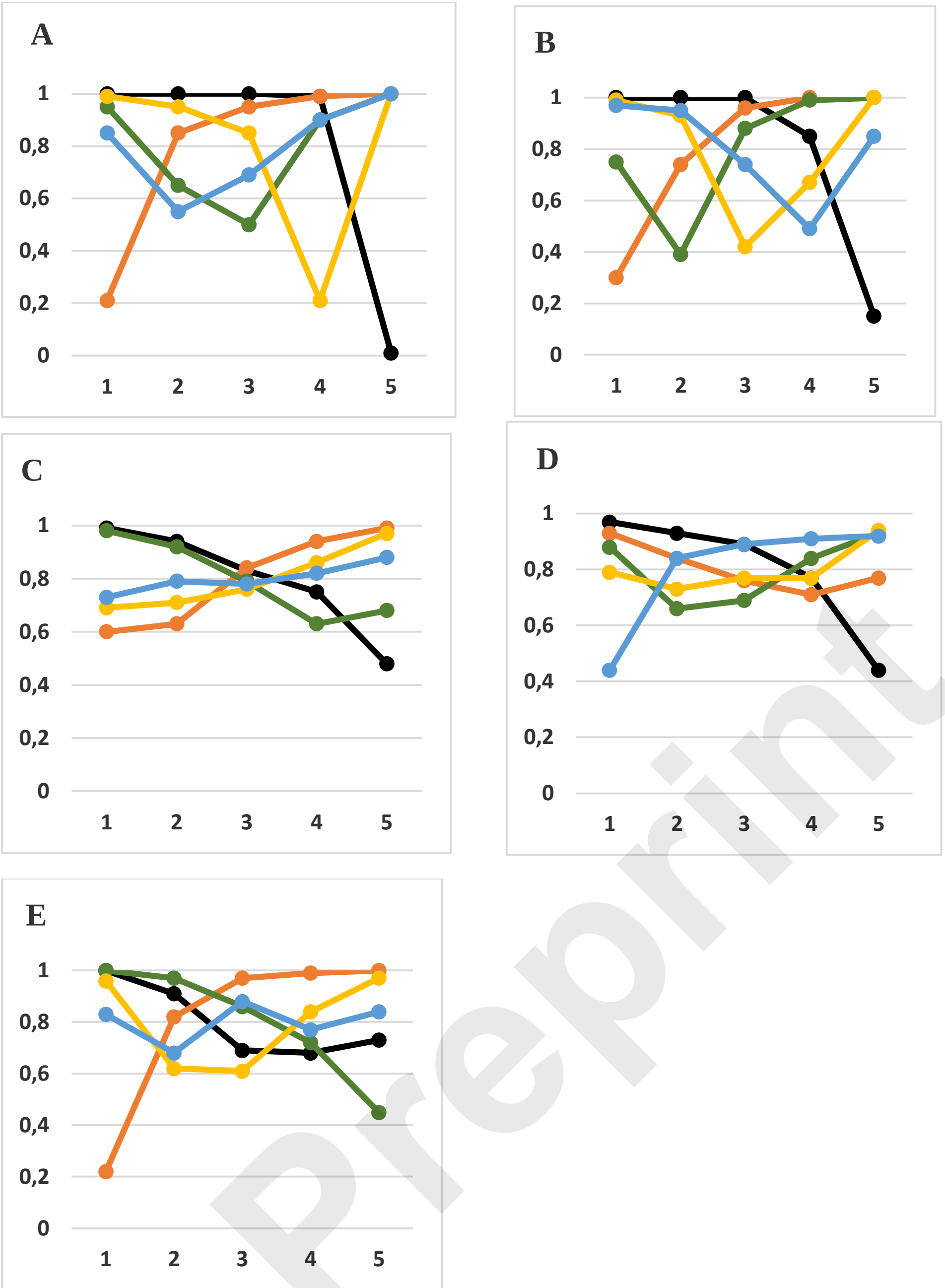

Figure 8. Ranking chart for the probability of best, second, third and fourth treatment for (A) major adverse cardiac events, (B) target lesion revascularization, (C) myocardial infarction (D) all-cause mortality, and (E) stent thrombosis and between DKcrush, crush, culotte and TAP techniques compered to Provisional technique in treatment of left main disease.