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Safety and efficacy of radial versus femoral access for rotational Atherectomy: A systematic review and meta-analysis☆,☆☆

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A R T I C L E I N F O

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Introduction: Over the recent years, there has been increased interest in the use of transradial (TR) access for percutaneous coronary intervention (PCI), including rotational atherectomy (RA). However, a large proportion of operators seem to be reluctant to use TR access for complex PCI including rotational atherectomy for heavily calcified coronary lesions.
Methods: We searched MEDLINE, ClinicalTrials.gov and the Cochrane Library for studies comparing radial versus femoral access in patients undergoing RA. Studies were included if they reported at least one of the following outcomes in each group separately: major adverse cardiac events (MACE), major bleeding, stent thrombosis, myocardial infarction (MI), hospital length of stay, radiation exposure, procedure time, procedure success and all-cause mortality. Odds ratio (OR) or mean difference (MD) with 95% confidence interval (CI) were calculated and a p-value of <0.05 was considered as a level of significance.
Results: This meta-analysis included 5 retrospective studies with 3315 patients undergoing RA via radial access and 5838 patients via femoral access. Radial access was associated with lower major access site bleeding (OR: 0.45, 95% CI: 0.31–0.67, $p < 0.001$), and radiation exposure (MD: −16.1, 95%CI: −25.4–−6.7 Gy cm^2, $p = 0.0007$). There were no significant differences observed in all-cause in-hospital mortality (OR: 0.92, 95% CI: 0.69–1.23, $p = 0.58$); MACE (OR: 0.80, CI: 0.63, 1.02, $p = 0.08$), stent thrombosis (OR: 0.28, 95%CI: 0.06–1.33 $p = 0.11$); and MI (OR: 0.43, 95%CI: 0.15–1.24, $p = 0.12$). There were no significant differences in hospital stay, procedure time or procedure success between the two groups ($p > 0.05$).
Conclusion: This meta-analysis of 9153 patients from observational studies demonstrates similar all-cause mortality, MACE, procedural success and procedural time during RA performed using TR access and TF access. However, TR access was associated with decreased access site bleeding and radiation exposure. Given the observational nature of these findings, a randomized controlled trial is warranted for further evidence.

1. Introduction

Heavily calcified coronary lesions continue to pose therapeutic challenges during coronary interventions. With better survival and an increasing octogenarian population, patients with heavily calcified lesions are frequently being referred for percutaneous coronary interventions (PCI). Rotational atherectomy (RA) provides an important means of treatment for such lesions. First performed in 1989 [1], the procedure has since evolved and is being used more as a plaque modifier for calcific lesions allowing improved balloon dilation and stent deployment rather than its use as a debulking tool [2]. Over the past decade, there has been a significant increase in the use of transradial (TR) approach for coronary angiography and interventions, due to reduced vascular and bleeding complications, and improved patient comfort. However, there is a

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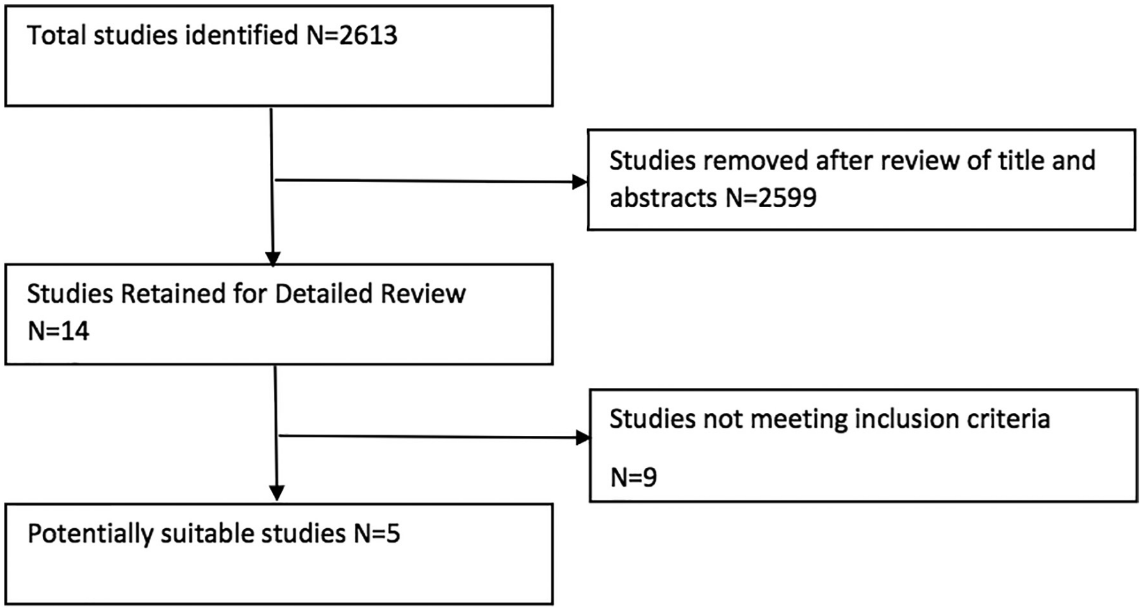

Fig. 1. Study selection process.

perception among operators that TR access may not provide sufficient support for the treatment of complex coronary disease including heavily calcified lesions and chronic total occlusions. In addition, many interventionalists feel limited in their options to choose larger burrs with the TR approach because of the small radial artery diameter that may only allow a maximum guiding catheter size of 6 Fr. There is limited data available in current literature supporting the role of TR access for RA. We sought to compare the short-term outcomes of patients undergoing RA via TR versus transfemoral (TF) access.

2. Methods

Electronic databases including MEDLINE, ClinicalTrials.gov and the Cochrane Library were searched for all clinical studies published until February 1, 2018 comparing the safety and efficacy of RA via radial versus femoral access. Articles not published in English language were excluded. The following key words were used for the search: “high speed rotational atherectomy”, “HSRA”, “radial”, “femoral”, “rotablation”, “rotational”, “atherectomy”, and “rotablator”. Additionally, references of key articles were manually searched. This Meta-analysis is being reported in accordance with the PRISMA statement [3] and MOOSE Guidelines [4].

Independently two investigators (AK and SZ) screened all studies and articles were selected that satisfied the following inclusion criteria: a) the study compared radial and femoral approach for RA for calcified native coronary artery lesions, b) the study reported at least one of the following outcomes: major bleeding, all-cause mortality, stent thrombosis, myocardial infarction (MI), major adverse cardiovascular events (MACE), hospital stay, radiation exposure, procedure time and procedure success. Studies were excluded if they were reviews, abstracts from conferences, or letters to the editor, and had less than five patients. Disparities and disagreements were resolved by consensus or group discussion with a third author (HBP).

The results of titles and abstracts of all relevant studies were merged into the Endnote software, and all duplicates were removed. Pre-specified data elements from all eligible studies were extracted on to a standardized dataset. The extraction was checked by another author (MP) independent of the first two (AK and SZ). The data included study characteristics, population under study, clinical outcomes and procedural characteristics.

The ‘Newcastle-Ottawa Scale’ was used to assess the quality of studies. This scale is recommended by the Cochrane Non-Randomized Studies Methods Working Group. The scale grades each study on three criteria; study group selection (maximum of four stars), comparability of the groups (maximum of 2 stars) and outcome assessment (maximum of 3 stars). Two independent reviewers performed the Newcastle-Ottawa Scale grading. Discrepancies were resolved with mutual consensus.

Mean difference (MD) or odds ratio (OR) were estimated with 95% confidence intervals (CI) for continuous and categorical variables

Table 1
Baseline characteristics.

Study	Country	Study design	Population type	Number of participants		Mean age (years)		Male (%)		ACC/AHA lesion type		Diameter stenosis %	
				RAD	FEM	RAD	FEM	RAD	FEM	RAD	FEM	RAD	FEM
Watt 2017 [8]	UK	Obs	RA	3069	5553	72.5 ± 0.17	73.0 ± 0.12	75.1	70.3	N/A	–	–	–
Kotowycz 2015 [12]	Canada	Obs	HSRA	52	67	71.0 ± 10.2	71.3 ± 10.5	83	64	A/B1: 0 B2: 33 C: 67	A/B1: 1 B2: 18 C: 81	–	–
Yin 2015 [14]	China	Obs	HSRA	59	67	69.3 ± 1.3	72.9 ± 1.6	71	51	All grade C	All grade C	80.5 ± 5.78	80.8 ± 5.93
Kassimis 2014 [11]	UK	Obs	HSRA	60	75	74.9 ± 8	74.6 ± 10	70	74	–	–	–	–
Watt 2009 [13]	UK	Obs	HSRA	75	76	68.2 ± 8.0	68.2 ± 10.0	73.3	59.2	B1/B2: 27.1 C: 72.9	B1/B2: 42.6 C: 57.4	92.6 ± 6.5	91.7 ± 5.5

Obs: observational study, RA: rotational atherectomy, HSRA: high speed rotational atherectomy, RAD: radial, FEM: femoral.
ACC/AHA: American College of Cardiology/American Heart Association.

respectively. Continuous variables reported as medians with low and high ends of the range were converted to means and standard deviations (SD) according to the method described by Hozo et al. [5] Ranges not directly reported were extracted using visual estimation of the graphs. Data expressed as medians and interquartile ranges were converted to means and SDs according to the method described by Wan et al. [6]. Heterogeneity between studies was assessed using a Cochran's Q statistic and the I^2 statistic [7]. A p value ≤0.05 and I^2 value of 50% or more was considered as evidence of heterogeneity. A fixed effects model was used for homogeneous study outcomes with inverse variance weights to derive the pooled effect estimate. The study by Watt et al. [8] has the largest sample size, which may skew the results. Thus a sensitivity analysis was performed excluding this study. Publication bias was assessed by visual inspection of the funnel plot [9]. All analyses were performed using RevMan 5.3 statistical software. (The Cochrane Collaboration Copenhagen, Denmark) [10].

3. Results

Study selection process is shown in Fig. 1. Five studies [8,11–14] met inclusion criteria and were selected for further analysis. The baseline study characteristics are presented in Table 1. Procedural characteristics and definitions of outcomes are outlined in Table 2 and Table 3 respectively. A total of 9153 patients were included. None of the studies were conducted in the United States or were randomized. The mean age of the participants ranged from 68 to 75 years. Almost all the studies had a high percentage of males. All studies were of sufficient quality to be included in the analysis (Table 4).

All the outcomes were homogeneous except for MACE as shown in Table 5. There was no evidence of publication bias for primary outcomes. The funnel plots are provided as supplementary material. The results demonstrate similar procedural success rate (OR: 1.08, CI: 0.89–1.32, $p = 0.44$), procedure time (MD: 0.98, CI: −4.88, 6.84, hours, $p = 0.74$), and length of hospital stay (MD: −0.06, CI: −0.88, 0.75 days $p = 0.88$) between radial and femoral approaches. There was no difference in in-hospital mortality (OR: 0.92, CI: 0.69–1.23, $p = 0.58$) and MACE (OR: 0.80, CI: 0.63, 1.02, $p = 0.08$) between the radial and femoral groups. Major access site bleeding (OR: 0.45, CI: 0.31–0.67, $p < 0.001$) and radiation exposure (MD: −16.1 CI: −25.4–−6.7, Gy cm^2, $p = 0.0007$) were noted to be significantly lower in the radial group compared to the femoral group. Incidence of MI (OR: 0.43, CI: 0.15–1.24, $p = 0.12$) and stent thrombosis (OR: 0.28, CI: 0.06–1.33, $p = 0.11$) were also similar between two groups. Sensitivity analysis excluding results from Watt et al. [12] revealed no changes in outcomes except for MACE which favors radial access for atherectomy.

4. Discussion

With the growing number of elderly patients with coronary artery disease, it is now increasingly common to see patients with calcific coronary lesions referred for PCI [15]. RA has been used for treating complex calcified coronary lesions with excellent outcomes. The present meta-analysis demonstrates that TR access is safe and effective approach to support the use of RA for heavily calcified lesions, with a similar procedural success rate and no difference in all-cause mortality compared to TF access.

TR access is known to be associated with lower rates of bleeding and vascular access complications, compared with TF access in patients undergoing PCI [16]. This pooled analysis extends these findings to patients undergoing RA for complex coronary disease with heavily calcified lesions. Bleeding during PCI is a well-known risk factor for increased mortality in patients presenting with acute coronary syndrome [17]. Bleeding often leads to the discontinuation of antithrombotic therapy, leading to a five-fold increase in the rate of stent thrombosis [17]. Even though our study showed reduced bleeding with TR access, mortality was similar between the TF and TR groups.

Table 2
Procedural characteristics.

Study	Heavily calcified lesion definition	Sheath size or guiding catheter (GC) size		Sheathless approach	Hemostasis device	Maximum Burr size		Anticoagulant	DAPT used	GP inhibitors	Drug eluting stent
		RAD	FEM			RAD	FEM				
Watt 2017 [8]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Radial: 13.7% Femoral: 14.9%	Radial: 87.9% Femoral: 82.9%
Kassimis 2014 [11]	Visualization of a heavily calcified coro-nary lesion or failure to cross/dilate the lesion with a balloon catheter	7.5 Fr SGC Eaucath	8 Fr GC	Radial: Yes Femoral: No	Radial: TR Band Femoral: Angioseal	1.75 (0.75–2.00) Femoral:	1.75 (1.25–2.5)	IV UFH	Not specified	Abciximab or bivalirudin (operator dependent)	N/A
Kotowycz 2015 [12]	Not available	6.31 ± 0.47	6.79 ± 0.59	Radial: Yes Femoral: No	N/A	1.75 ± 0	1.88 ± 0.18	IV UFH	Aspirin & Clopidrogrel	Radial: 28 (54%) Femoral: 35 (52%)	Radial: 20 (38%) Femoral: 27 (40)
Yin 2015 [14]	Not available	6 F: 59% 7 F: 31%, 8F:10%	6 F: 10% 7 F: 78%, 8F:12%	Radial: No Femoral: No	Radial:hemostatic bandage (Stepy®P) Femoral: compression and gauze pressure dressings with sand bag	1.39 ± 0.16 (mean)	1.53 ± 0.24 (mean)	IV UFH	Aspirin & Clopidrogrel	N/A	Radial: 51 (96%) Femoral: 55 (92%)
Watt 2009 [13]	visualization of a heavily calcified coronary lesion or failure to cross/dilate	6.3 ± 0.5	7.1 ± 0.8	Radial: No Femoral: No	Radial: Radistop Femoral: Femostop/manual pressure/femoral artery closure device	1.6 ± 0.2	1.7 ± 0.2	IV UFH	DAPT (unspecified)	Radial: 49.3% Femoral: 42.1%	Radial: 64 (85.3%) Femoral: 53 (69.7%)

DAPT: Dual Antiplatelet Therapy, UFH: Unfractionated Heparin, GP: Glycoprotein, TR: transradial, RAD: radial, FEM: femoral.

Table 3
Definitions of outcomes.

	MACE
Watt 2017 [8]	Composite of 30-day mortality, in-hospital myocardial infarction, in-hospital target vessel revascularization, or in hospital cerebrovascular event
Kotowycz 2015 [12]	Composite of death, MI, and urgent bypass surgery (CABG).
Yin 2015 [14]	Death, recurrent non-fatal MI, recurrent non-fatal stroke, and TVR
Kassimis 2014 [11]	Undefined
Watt 2009 [13]	Death and/or MI
	Target Vessel Revascularization
Watt 2017 [8]	Undefined
Kotowycz 2015 [12]	Need for CABG surgery
Yin 2015 [14]	Need for a new revascularization, either percutaneous or surgical
Kassimis 2014 [11]	Undefined
Watt 2009 [13]	Repeat percutaneous or surgical intervention of the treated lesion
	Procedure Success Rate
Watt 2017 [8]	Defined by local operator
Yin 2015 [14]	TIMI flow grade 3 and reduction of the target lesion to <20% luminal diameter by visual angiographic assessment in the absence of complications
Kotowycz 2015 [12]	TIMI flow grade 3 and reduction of the lesion to <30% luminal diameter by visual angiographic assessment in the absence of complications
Kassimis 2014 [11]	Undefined
Watt 2009 [13]	Reduction of the target lesion to <30% luminal diameter by visual angiographic assessment in the absence of complications
	Major Bleeding
Watt 2017 [8]	Gastrointestinal, intracranial or retroperitoneal bleeding, pericardial bleeding causing tamponade, or any bleeding requiring blood or platelet transfusion or resulting in surgery.
Kotowycz 2015 [12]	Bleeding causing hemodynamic compromise or blood transfusion
Yin WH 2015 [14]	Hemodynamic compromise and/or blood transfusion.
Kassimis 2014 [11]	Hemodynamic compromise and/or blood transfusion.
Watt 2009 [13]	Bleeding requiring blood transfusion
	All-Cause Mortality
Watt 2017 [8]	30 Day In hospital mortality
Kotowycz 2015 [12]	All cause In-hospital mortality
Yin WH 2015 [14]	All cause In-hospital mortality
Kassimis 2014 [11]	All causes of mortality during the index admission.
Watt 2009 [13]	All causes of mortality during the index admission
	Myocardial Infarction
Watt 2017 [8]	Undefined
Kotowycz 2015 [12]	Creatine kinase rise of greater than twice the upper limit of normal
Yin WH 2015 [14]	Clinical evidence of new myocardial ischemia following the index procedure accompanied by new pathological Q-waves on EKG and/or an increase in CK-MB > 3 times upper limit of normal
Kassimis 2014 [11]	Undefined
Watt 2009 [13]	New myocardial ischemia accompanied by electrocardiographic changes after index procedure confirmed with Troponin I elevation
	Stent Thrombosis
Watt 2017 [8]	Undefined
Kotowycz 2015 [12]	Unavailable
Yin WH 2015 [14]	Defined according to the Academic Research Consortium criteria.
Kassimis 2014 [11]	Acute coronary syndrome (ACS) with angiographic evidence of stent occlusion.
Watt 2009 [13]	Acute coronary syndrome with angiographic evidence of stent occlusion.

TIMI: Thrombolysis in Myocardial Infarction, CABG: Coronary Artery Bypass Graft, TVR, MI: Myocardial Infarction CK-MB: Creatine kinase – muscle brain, EKG: Electrocardiogram.

Table 4
Newcastle-Ottawa scale quality assessment.

Study	Study type	Selection	Comparability	Outcome/exposure
Watt 2017 [8]	Observational	***	*	***
Kotowycz 2015 [12]	Observational	***	**	***
Yin WH 2015 [14]	Observational	***	*	***
Kassimis 2014 [11]	Observational	***	*	***
Watt 2009 [13]	Observational	***	*	***

Because of the small size of the radial artery, TR access may only allow the use of relatively smaller burr sizes (up to 1.75 mm with a 6Fr guiding catheter). However, the TR procedural success rate was comparable to the TF approach with the added benefit of lower access site bleeding and vascular complications. The recent advent of sheathless guiding catheters or "slender" introducer sheaths has allowed accommodation of larger burrs without compromising safety and comfort with respect to the relatively small radial artery. The 7.5 Fr sheathless guide has an outer diameter of 2.49 mm, which is smaller than the outer diameter of a standard 6 Fr sheath of 2.70 mm [18,19].

Table 5
Test of heterogeneity and publication bias (funnel plot) for each outcome.

Outcomes	Chi-square	df	*p*-Value	I Square (%)	Results	Publication bias
Major bleeding	4.46	4	0.35	10	Homogenous	Yes
Myocardial infarction	0.83	2	0.66	0	Homogenous	No
Stent thrombosis	0.46	2	0.79	0	Homogenous	Yes
In hospital mortality	1.19	3	0.75	0	Homogenous	No
MACE	6.70	3	0.08	55	Heterogeneous	Yes
Procedural success rate	3.43	4	0.49	0	Homogenous	No
Radiation exposure	3.71	2	0.16	46	Homogenous	No
Procedure time	1.32	1	0.25	24	Homogenous	No
Hospital stay	1.51	1	0.22	34	Homogenous	No

MACE: Major adverse cardiac events; df: Degrees of freedom.

Study or Subgroup	Radial Events	Radial Total	Femoral Events	Femoral Total	Weight	Odds Ratio M-H, Fixed, 95% CI	Year
Watt 2009	0	75	1	76	1.6%	0.33 [0.01, 8.31]	2009
Kassimis 2014	0	60	0	75		Not estimable	2014
Yin WH 2015	0	59	1	67	1.5%	0.37 [0.01, 9.32]	2015
Kotowycz 2015	1	52	3	67	2.7%	0.42 [0.04, 4.14]	2015
Watt 2017	67	3069	127	5553	94.2%	0.95 [0.71, 1.29]	2017
Total (95% CI)		**3315**		**5838**	**100.0%**	**0.92 [0.69, 1.23]**	
Total events	68		132				

Heterogeneity: Chi² = 1.19, df = 3 (P = 0.75); I² = 0%
Test for overall effect: Z = 0.55 (P = 0.58)

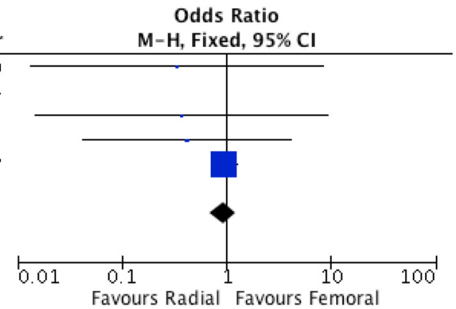

Fig. 2. Meta-analysis comparison of in hospital mortality rates between radial and femoral routes for rotational atherectomy.

Study or Subgroup	Radial Events	Radial Total	Femoral Events	Femoral Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Kotowycz 2015	4	52	9	67	4.8%	0.54 [0.16, 1.85]
Watt 2009	1	75	6	76	3.9%	0.16 [0.02, 1.34]
Watt 2017	94	2969	191	5401	86.0%	0.89 [0.69, 1.15]
Yin WH 2015	1	59	9	67	5.4%	0.11 [0.01, 0.91]
Total (95% CI)		**3155**		**5611**	**100.0%**	**0.80 [0.63, 1.02]**
Total events	100		215			

Heterogeneity: Chi² = 6.70, df = 3 (P = 0.08); I² = 55%
Test for overall effect: Z = 1.77 (P = 0.08)

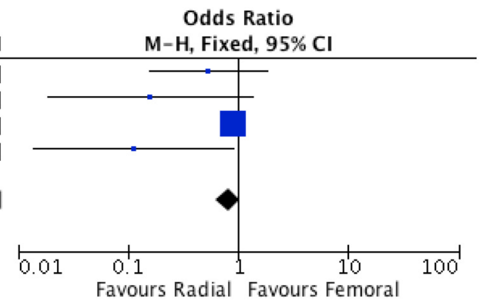

Fig. 3. Meta-analysis comparison of Major Adverse Cardiac events (MACE) between radial and femoral routes for rotational atherectomy.

These guides have been successfully used to perform complex interventions requiring large burrs of up to 2.0 mm [11,20]. With the recent emphasis on plaque modification rather than debulking, increasingly more operators find the maximum burr size of 1.75 mm to be adequate to meet their needs. Thus a burr-to-artery ratio of <0.7 is often sufficient, allowing for the use of smaller burrs and guides [21]. Although procedural success and hospital length of stay both numerically favored the TR group, there was no statistically significant difference between the two groups. While recognizing that these results can mostly be applied to centers with sufficient operator experience, there appears to be no procedural disadvantage to the TR approach.

In contrast with previous studies [22], procedural radiation exposure was significantly lower in the TR group. Kuiper et al. [23] and Geijer et al. [24] reported similar procedural radiation exposure in patients undergoing complex PCI with the TR and TF approaches. These findings may be limited to high-volume and skilled operators that frequently perform RA. As a matter of fact, the RIVAL trial showed that radiation exposure was lowest, without differences between TR and TF interventions in high volume centers with high volume operators [25]. Delawi et al. reported no significant difference in radiation exposure between femoral and radial cases when performed by experienced radial operators [26]. Although none of the studies analyzed had major differences in the severity of coronary artery disease, it is possible that operators that performed the TR RA were more experienced and patients had lesser extent of disease severity and complexity, accounting for the differences observed in our meta-analysis. Patients in the TF group were also noted to have a higher body mass index and may have also accounted for the increased radiation exposure. Overall, the lower radiation exposure with TR access in this and other contemporary studies is likely multifactorial, and related to better operator expertise, less sick patients and advances in technology [27]. (See Figs. 2–10.)

5. Limitations

The results of this study need to be interpreted in light of the study limitations. The baseline differences between the two groups could not be compared due to the inherent nature of the meta-analysis. The follow-up period was short in most studies, preventing us from reporting long-term outcomes. Power analysis was lacking for most studies, and most of these studies may have been underpowered. All included studies are retrospective in nature as there are no published randomized controlled trials assessing TR access for RA. Meta-analysis of non-randomized aggregated data including this work should be interpreted with caution due to the presence of inherent confounding and selection biases. Such biases may compromise the validity of the results due to imbalance in factors associated with outcomes of interest

Study or Subgroup	Radial Events	Radial Total	Femoral Events	Femoral Total	Weight	Odds Ratio M-H, Fixed, 95% CI	Year
Watt 2009	70	75	72	76	2.5%	0.78 [0.20, 3.02]	2009
Kassimis 2014	60	60	72	76	0.3%	7.51 [0.40, 142.29]	2014
Yin WH 2015	57	59	66	67	1.1%	0.43 [0.04, 4.89]	2015
Kotowycz 2015	50	52	61	67	1.1%	2.46 [0.48, 12.72]	2015
Watt 2017	2906	3052	5173	5449	95.0%	1.06 [0.86, 1.30]	2017
Total (95% CI)		**3298**		**5735**	**100.0%**	**1.08 [0.89, 1.32]**	
Total events	3143		5444				

Heterogeneity: Chi² = 3.43, df = 4 (P = 0.49); I² = 0%
Test for overall effect: Z = 0.77 (P = 0.44)

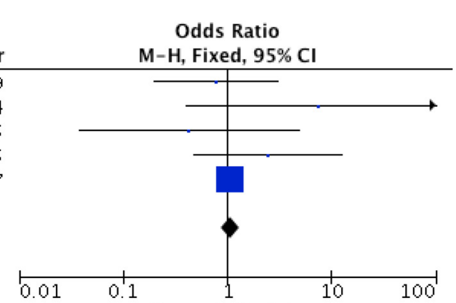

Fig. 4. Meta-analysis comparison of procedural success rates between radial and femoral routes for rotational atherectomy.

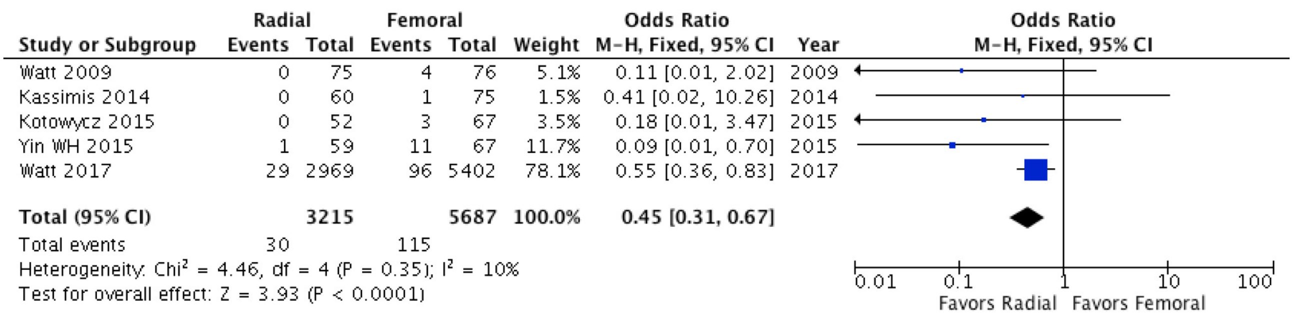

Fig. 5. Meta-analysis comparison of major bleeding rates between radial and femoral routes for rotational atherectomy.

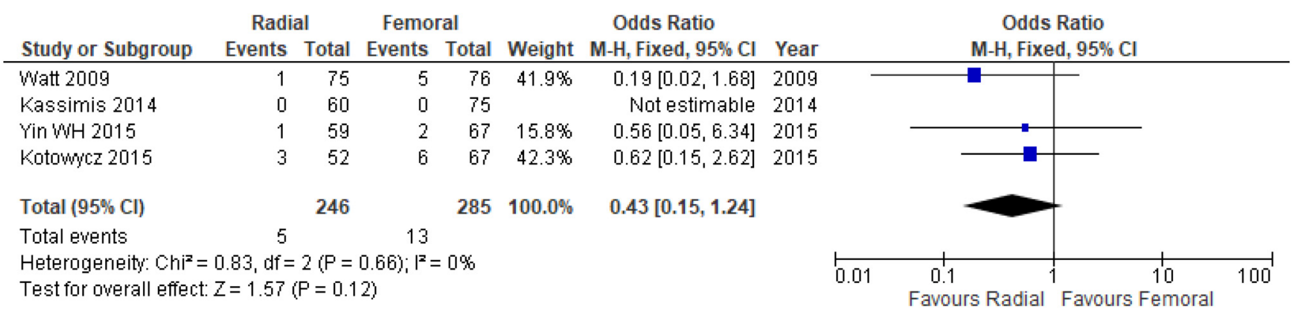

Fig. 6. Meta-analysis comparison of myocardial infarction rates between radial and femoral routes for rotational atherectomy.

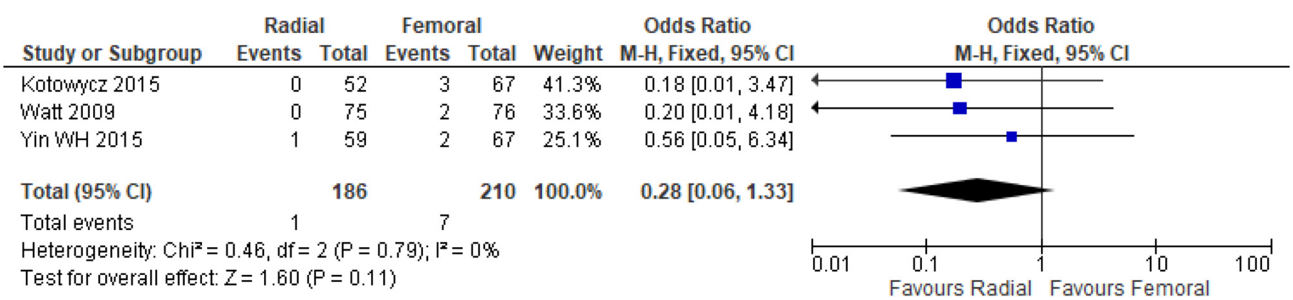

Fig. 7. Meta-analysis comparison of stent thrombosis between radial and femoral routes for rotational atherectomy.

[28]. Although the likelihood of increased heterogeneity resulting from residual confounding and biases cannot be completely mitigated, we used random effect modeling to overcome these issues. The study by Watt et al. had significantly higher weight in the analysis due to relatively larger sample size that may sway the pooled results in its favor. We attempted to mitigate this by performing a sensitivity analysis excluding the study by Watt et al. No changes in included outcomes were observed with the exception of MACE, which favors radial access for atherectomy. However, this study had the largest sample size and was therefore included in the analysis. Confounding and selection bias due to cross over, underlying disease severity, operator experience and difference in baseline characteristics could not be excluded. This could have influenced radiation exposure and contrast volume, which tend to vary from operator to operator. Despite all these limitations, the results of this study should encourage operators to consider TR access for complex PCI including RA.

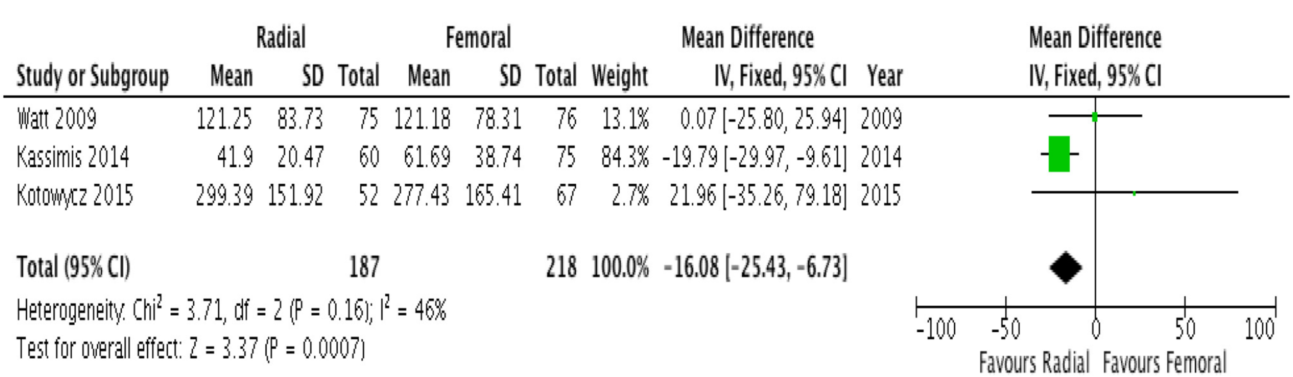

Fig. 8. Meta-analysis comparison of radiation exposure between radial and femoral routes for rotational atherectomy.

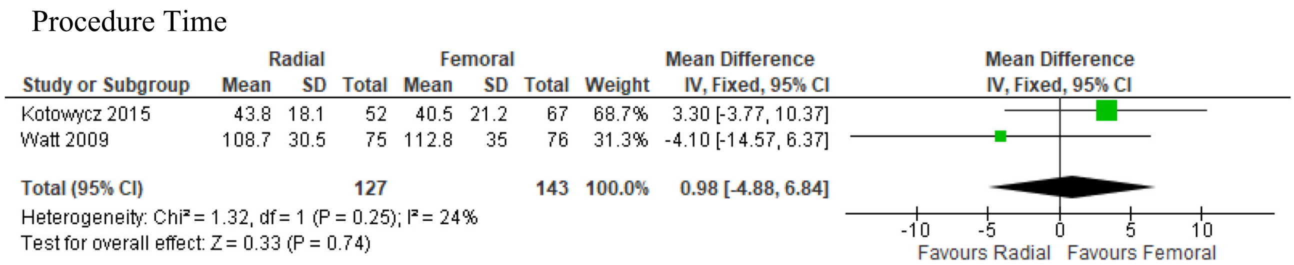

Fig. 9. Meta-analysis comparison of procedure time between radial and femoral routes for rotational atherectomy.

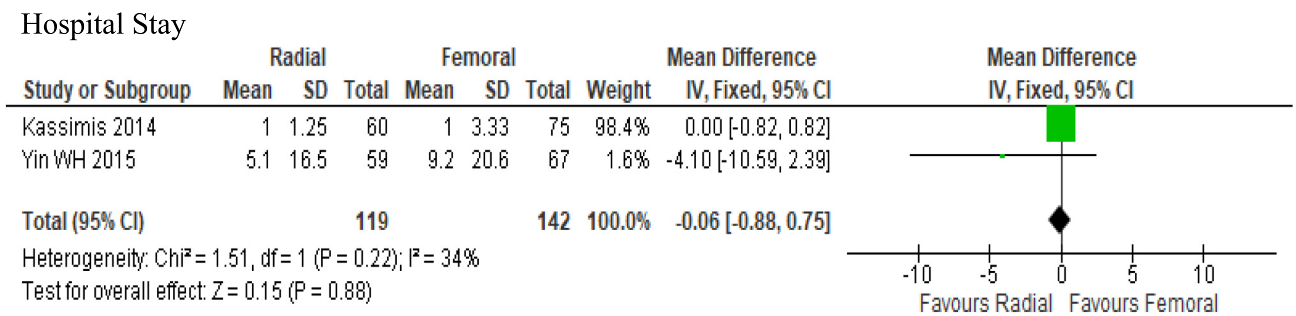

Fig. 10. Meta-analysis comparison of hospital stay between radial and femoral routes for rotational atherectomy.

6. Conclusion

Radial approach for RA of calcified native coronary lesion is associated with lower rate of access site bleeding, and radiation exposure but comparable procedural success, procedural time, all–cause mortality and MACE compared to femoral approach. With increasing operator experience and higher volume, RA via radial artery and subsequent PCI is a reasonable option in the treatment of heavily calcified coronary lesions. Randomized trials are needed for further evidence.

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