

# Expanded role of one stage indications in total knee arthroplasty revision

**Keywords:** Single stage, one stage, direct exchange, prosthetic joint infection, total knee arthroplasty

## Background

The utilization of total knees has a projected increase to 3.48 million cases by 2030. Revisions are also projected to increase 601% from 2005-2030 to 268,200 cases, 65.5% of which are projected to be revisions related to infection.<sup>1</sup> In 1983 John Insall MD described a two stage revision approach as a way to salvage an infected total knee arthroplasty (TKA) with 11 knees and no recurrences. It was noted that the method was both “costly and time-consuming.”<sup>27</sup> Despite cost and time consumption, a two stage has become and remained the gold standard of TKA infection management.<sup>3</sup> Alternatives for infection management are limited to irrigation and debridement, resection arthroplasty, arthrodesis, amputation, chronic suppression and one stage revision arthroplasty.<sup>4,5</sup> Two stage revision failure rates have been variable between 0-41%<sup>6</sup> with average failure rates being found to be between 17.3-18%.<sup>7,8</sup> In addition to risks for reduced mobility, recurrent infection, stiffness/contracture, instability and spacer fracture,<sup>9</sup> two studies regarding two stage revision arthroplasties have been published showing significantly elevated mortality rates at 90days of 1.7-4%, up to 16% at 5years and 22% overall.<sup>7,10</sup>

As an alternative, single stage management for infected TKA's have been utilized starting back to 1975<sup>11</sup> and more widely adopted in specialized centers in Europe over the years.<sup>12</sup> One stage arthroplasty leaves the possibility of minimizing stiffness, arthrofibrosis, and cost in comparison to two stage technique.<sup>4,13</sup> The purpose of this paper is to explore what has been learned from currently published data regarding one stage revisions and to see if the “gold standard” in the United States should be evolving for certain patient populations where we can spare the excess burden of time, resources and potential compromised outcomes that a two stage may lend.

## Methods

A review of the literature on one stage revision arthroplasties was performed and assessed in regards to infection recurrence but also in regards to patient selection, surgical technique, and postoperative antibiotic management, as to better gain an understanding of the potential indications for a one stage arthroplasty revision

## Results

One stage TKA results have ranged in success for infection eradication from 73% to 100% (Table 1). There has been a trend towards more success with infection eradication in more recently published studies without changes in duration of follow-up.<sup>14</sup> This can be for a variety of reasons including: a better understanding of bacteria, biofilm, sensitivities, antibiotic options, cement makeup, IV and PO antibiotics and the duration of therapy required and utilization of chemical debridement to supplement mechanical debridement. The key lies in attempting to predict whom a one stage will be most successful in and if two stage revision remains necessary in certain patient populations. The host seems to play

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a large role in infection, therefore patient selection seems to be fundamental in the success of surgical intervention. Multiple studies have published their recommendations on criteria for who qualifies for one stage intervention in infected TKA.<sup>12,15-17</sup> Recommendations put forth by the International Society for Infectious disease for one stage arthroplasty included: patients with: no need for bone graft, an aggressive debridement of all infected tissue, satisfactory soft tissue, absence of difficult to treat microorganisms, and a bacteria that is sensitive to antibiotic cement.<sup>3</sup> There seems to be agreement that an unknown pathogen or a known pathogen of high virulence, acutely decompensated or systemically ill patients, significant soft tissue involvement and general medical contraindications such as immunocompromised states are not optimal candidates for one stage arthroplasty. Silva et al. concluded that 4 important factors contributing to the success of two stage outcomes lies in having a gram positive infection, usage of antibiotic cement with replantation, 12weeks of postoperative antibiotics and the absence of a sinus tract.<sup>5</sup>

The question lies in how patients perform with strict criteria applied, knowing that around 18% of patients fail two stage revisions without such criteria,<sup>5</sup> and then extrapolating, how have one stage revisions performed with less strict inclusion criteria. Utilizing strict patient exclusion criteria, including local factors (skin, soft tissue bony defects/quality, peripheral vascular disease), host factors (immunosuppression, sepsis, reinfection, systemic disease) and organism factors (unknown, resistant or poly bacterial infection) Haddad et al. was able to achieve a 100% success rate at 36month average among 28patients.<sup>17</sup> Singer et al.,<sup>18</sup> did not limit based on host factors, however, excluded MRSA, MRSE, and unknown pathogens as well as wound defects unable to be primarily closed, found a 95% success rate among 63patients.<sup>18</sup> Both of these selective studies certainly faired well in regards to 2stage success rates in the literature. Interestingly, as many studies suggest soft tissue coverage need, sinus tracts, polymicrobial infections or resistant bacteria are contraindications to a one stage TKA; these also are similar factors that lead to a higher risk of re-infection in two stage revision arthroplasty.<sup>6,7</sup> Mortazavi et al in their review of two stage arthroplasty studies concluded that culture negative infection and resistant bacteria led to a 4 and 2 fold respectively increased risk of failure.<sup>8</sup>

In regards to how one-stage revisions have fared in a more complex patient population, one of the largest one-stage TKA studies published to date by Zahar et al.<sup>15</sup> obtained 93% success in infection

eradication at 120month mean follow-up.<sup>15</sup> Exclusion criteria was limited to negative preoperative aspiration for culture, allergy to cement, and involvement of NV structures. As such, patients were included irrespective of host factors such as: ASA, BMI, sinus tracts or flap requirement. Twenty-one patients were included who had MRSA/MRSE(9), fungal(1), polymicrobial(3), gram negative(8) infections. These success rates were also obtained despite limited post operative antibiotic usage of 14days average without prolonged oral antibiotics. Bauer et al.,<sup>19</sup> also concluded in comparison of 30 single-stage vs 77 two-stage TKAs found that chronicity of infection, number of prior surgeries and bacterial virulence/resistance were not predictive of failure of one surgical technique over another.<sup>19</sup> Jenny et al.<sup>20</sup> achieved an 87% success rate (91% from initial infection) despite including 5patients who required soft tissue flaps and 11 polymicrobial

infections.<sup>20</sup> Fungal infections and repeat failures of 2 prior infections were not included. Three of the 6infections were recurrent, whereas 3 were different bacteria isolated at time of infection and not true recurrences.<sup>20</sup> There has been one study looking at 4 knees with known fungal infections, which were treated with single stage revision arthroplasty. Three of the 4 were successfully treated as of 7yrs mean follow up.<sup>21</sup> Interestingly, 75% of the fungal infections were also bacterial infected re-enforcing that isolated antifungal therapy may not be appropriate treatment. Ultimately, a more lax selection criteria is not proven definitively in the literature to provide better success rates with two stage over one stage leading to Kunustor et al. to conclude that “one stage TKA’s may be as effective as two- stage in treating infected TKA in generally unselected patients.”<sup>22</sup>

**Table 1** Single stage TKA results

	Patient number	Follow up (months)	Success (%)	Published
Freeman et al. <sup>11</sup>	8	12 to 40	100	1985
Von Forester et al. <sup>28</sup>	104	75.5	73.1	1991
Goksan & Freeman <sup>29</sup>	18	60	88.8	1992
Lu et al. <sup>30</sup>	8	20.1	87.5	1997
Buechel et al. <sup>31</sup>	22	122.4	90.9	2004
Sofer et al. <sup>32</sup>	15	18.4	93	2005
Whiteside <sup>24</sup>	18	62	94.4	2011
Parkinson et al. <sup>4</sup>	12	24	100	2011
Singer et al. <sup>18</sup>	63	35.9	95	2012
Jenny et al. <sup>20</sup>	47	36	87	2013
Tibrewal et al. <sup>23</sup>	50	126	98	2014
Klatte et al. <sup>21</sup>	4	84	75	2014
Haddad et al. <sup>17</sup>	28	78	100	2014
Zahar et al. <sup>15</sup>	70	120	93	2015

## Surgical technique

Standardizing a surgical technique is another important factor which will lead to more consistently reliable results in terms of infection management. Tibrewal et al.<sup>23</sup> from the George et al.<sup>16</sup> in Canada both detail similarity in their papers.<sup>16,23</sup> Surgical technique at a minimum consists of explant of all components and cement, obtaining tissue for culture from separate sites, radical irrigation and debridement of all involved tissue including posterior capsule, bone etc.. Next, most techniques describe some form of chemical debridement, George et al. utilizing hydrogen peroxide 3% solution and betadine,<sup>16</sup> others using polyhexanide<sup>21</sup> or Octenidine dihydrochloride.<sup>18</sup> The wound is temporarily closed while it continues to soak in betadine. The contaminated instruments, gowns/gloves and drapes are all changed and the patient is re-prepped for the replant while the surgical team rescrubs. The betadine is irrigated out of the wound and re-implantation ensues with antibiotic cement based on bacterial sensitivities. Antibiotic pellets are placed in the tissue throughout closure. In treating the case as two separate procedures,

explant and then replant, the chances of cross contamination as opposed to true recurrence due to ineffective initial debridement would seem to be minimized.

## Antibiotic management

In regards to antibiotics, most facilities defer to infectious disease in regards to selection, duration of treatment with IV, need for oral therapy etc... The International Society for Infectious Disease recommends 2weeks of IV therapy followed by 6months of oral therapy for prosthetic knee joint infections.<sup>3</sup> There was not a general acceptance as to the duration of antibiotic therapy in this pool of international studies as it ranged from as little as 5days IV with conversion to orals,<sup>16</sup> to 10-17days IV without prolonged oral therapy<sup>15</sup> to intraarticular infusion for 6weeks.<sup>24</sup> As mentioned, alternatives to systemic antibiotic therapy have been and continue to be explored ,as Whiteside et al.<sup>24</sup> described a technique involving single stage knee revision plus Hickman intraarticular infusion of IV vancomycin, which hope to provide elevated antibiotic concentrations

where they are needed most while minimizing systemic toxicity issues.<sup>24</sup> This resulted in a 94% success rate in 17/18 patients. This was again described in 2017 in the hip where 20/21 patients had success eradication with a similar technique.<sup>25</sup> Most facilities see 4–6 weeks IV therapy as a common duration for IV antibiotic therapy in the United States in addition to an antibiotic cement spacer.<sup>26</sup>

## Conclusion

As more evidence is compiled on the management of infection with one stage TKA, there may be an expanding role for its use to minimize infection recurrence while at the same time optimizing patient outcome and improving upon cost and resource utilization. In the two meta-analyses published to date on single stage knee revision,<sup>6,14</sup> both reiterate that there is a much larger body of literature on two stage revisions and until larger studies of more quality are done on one stage TKA revisions, the gold standard remains two stage by default. A standardized technique for patient inclusion/exclusion, preoperative workup, mechanical and chemical debridement, antibiotic management based on sensitivities, for one stage, remains necessary. At a minimum, knowing the involved pathogen preoperatively should remain the most basic of criteria for one stage TKA revision with factors such as patients ability to undergo further operations, virulence of bacteria involved, medical comorbidities remaining at the discretion of the surgeon and infectious disease specialists, along with patient education on risks and benefits of a one stage vs two stage arthroplasty. Currently a multicenter trial is undergoing active enrollment among tertiary care centers in the United States which will hopefully be able to shed more light on the subject in regards to further standardization among patient selection surgical techniques and post-operative management to optimize management of prosthetic knee infection in a manner that optimizes patient outcomes in as conservative a manner as possible.<sup>27</sup>

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## Conflict of interest

Authors declare that there is no conflict of interest.

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