

# ACL surgical innovation cycles: what goes around, comes around

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## ABSTRACT

Over the past 45 years, the 'gold standards' for ACL surgery have evolved considerably. Many discoveries in the field of ACL surgery seem to come and go, in cycles. The aim of this paper was to confirm these cyclic phenomena by methodically researching the ACL literature. It proposes a bibliometric research of the literature over the last 45 years to assess temporal changes in publications on 3 topics of high interest in ACL surgery for which we hypothesised a cycle phenomenon: surgery to address anterolateral knee instability, ACL repair and prosthetic ACL reconstruction grafts. We searched PubMed from 1975 to 2019 with different equations and different Boolean operators. Review results are presented as graphs depicting the evolution of the annual publication number over the total number of PubMed results that year. Graph analysis confirmed cycles of interest in these 3 fields. When this analysis was put into perspective with the major historical articles in each field, cycles seem to have 5 typical phases: hope, inflation, disillusion, eclipse and rebirth. The initial hope-inflation and rebirth phase trend peak interval was approximately 35 years. Rebirth trend peak slope trajectories for each topic seemed to display more rapid and stronger rise times than the initial trend peak slope trajectories. These cyclic phenomena that were observed suggest that knee surgeons need to better balance early enthusiasm and hope for innovative surgical practice efficacy with the guidance of both scientific rigour derived evidence and history.

## INTRODUCTION

Since the 1960s, orthopaedic surgeons have been searching for the best ACL restoration method. Over the past 45 years, the 'gold standards' for ACL surgery have evolved considerably. As in other orthopaedic subspecialties, surgeons have been positive and enthusiastic about new concepts. Many discoveries seem to come and go in cycles with somewhat consistent characteristics.

A typical cycle includes: *Hope*: where a new concept raises interest with 'landmark' publication. However, with this we tend to jump too early, accepting unproven conclusions, often forgetting the need for scientific rigour. This is followed by *Inflation*: where the concept is quickly embellished by a number of supportive 'follower' papers.<sup>1</sup> After this, *Disillusion*: where over time, the new concept does not appear to be as promising as expected based on early hype. This is followed by an *Eclipse*: where surgeons jump to another concept in hopes of identifying another 'knight in shining armour' that may better stand the test of time. Lastly, *Rebirth*: during which a subsequent generation of

orthopaedic surgeons rediscover the initial concept. The aim of this paper was to confirm this cyclic phenomena by methodically researching the ACL literature. We present a historical bibliometric analysis that graphically assesses temporal changes in publications on three topics related to ACL surgery from 1975 through 2019. The analysis will then be put into perspective with the major historical articles.

## MATERIALS AND METHODS

### Study design: a historical bibliometric analysis

We hypothesised three subjects to have sustained a cyclic phenomenon of interest in ACL surgery: surgical procedures to address anterolateral knee instability, ACL repair and synthetic ACL reconstruction grafts. These three topics were selected as in our opinion they presented the highest interest and motivated changes in clinical practice in ACL surgery over the last decades. For each topic we performed separate PubMed searches from 1975 to 2019 with different equations: different terms, combined with different Boolean operators (AND, OR, NOT). MeSH (Medical Subject Headings) terms were included. Truncating search terms were analysed as well. For each query, PubMed provided the total number of citations, as well as the number of citations/year. Yearly count for each query was obtained by adding 'AND year (DP)' to the PubMed query ([DP]: search field for Publication Date). As there is an increase of publications each year for all subjects, the interest for a subject had to be interpreted in the light of the total number of publications as citations increase in all fields each year. This total is available on: [https://www.nlm.nih.gov/bsd/medline\\_cit\\_counts\\_yr\\_pub.html](https://www.nlm.nih.gov/bsd/medline_cit_counts_yr_pub.html). Review results are presented as graphs depicting the evolution of the annual publication number over the total number of PubMed results that year, multiplied by 100 000.<sup>2</sup>

Preliminary analysis of the literature on PubMed between 1945 and 1975 following the equations described below has shown that the number of publications indexed over that period was negligible (anterolateral instability  $n=0/460$ ; ACL repair  $n=13/2546$ ; synthetic ACL reconstruction grafts  $n=4/651$ ). Therefore, the decision was made to exclude that time period from data analysis.

### Data collection

To analyse interest for surgical procedures in anterolateral knee instability, we used the following equation:

'(anterolateral'(All Fields) OR 'anterolateral-ly'(All Fields)) AND (((('knee'(MeSH Terms) OR



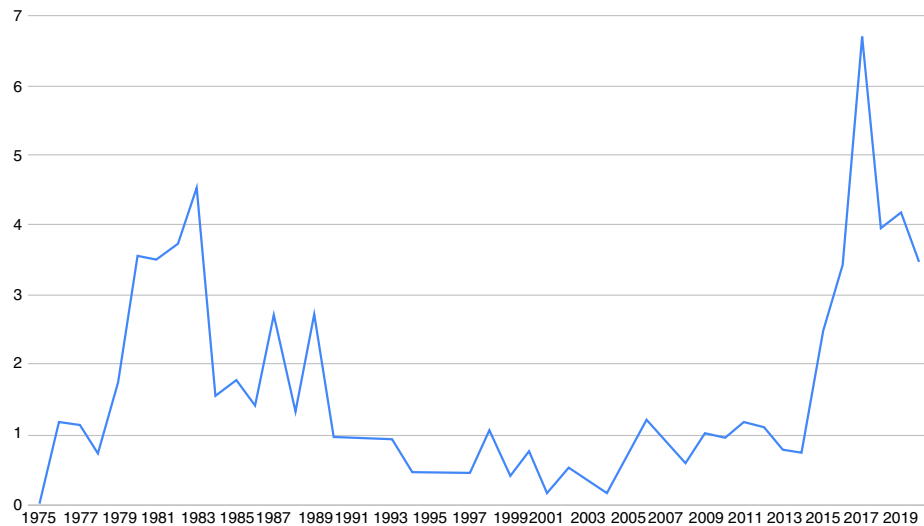
► <http://dx.doi.org/10.1136/jisakos-2020-000544>



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Results per 10,000 citations in PubMed  
Proportion for each search by year, 1975 to 2020



**Figure 1** Temporal trends in publications on surgical procedures to address anterolateral instability.

'knee'(All Fields) OR 'knee joint'(MeSH Terms) OR ('knee'(All Fields) AND 'joint'(All Fields)) OR 'knee joint'(All Fields) AND (('instabilities'(All Fields) OR 'instability'(All Fields) OR 'instable'(All Fields)). For ACL repair, we used the following equation: ('REPAIR'(All Fields) OR 'STABILIZATION'(All Fields)) AND (('anterior cruciate ligament'(MeSH Terms) OR (('anterior'(All Fields) AND 'cruciate'(All Fields)) AND 'ligament'(All Fields)) OR 'anterior cruciate ligament'(All Fields) OR 'acl'(All Fields)). Finally, for synthetic ACL reconstruction grafts we used the following equation: '((((('polyethylene terephthalates'(MeSH Terms) OR ('polyethylene'(All Fields) AND 'terephthalates'(All Fields))) OR 'polyethylene terephthalates'(All Fields) OR 'dacron'(All Fields) OR 'LAD'(All Fields) OR 'LARS'(All Fields) OR 'polyethylene terephthalate'(All Fields) OR ('silk'(MeSH Terms) OR 'silk'(All Fields))) AND (('ligament s'(All Fields) OR 'ligaments'(MeSH Terms)) OR 'ligaments'(All Fields) OR 'ligament'(All Fields))'

## RESULTS AND DISCUSSION

### Temporal trends in research production

#### Surgical procedures to address anterolateral instability

A total of 460 citations was identified on PubMed with the annual distribution displayed in figure 1.

In viewing figure 1, the reader can observe an example of the *Hope* component during the late 1960s, early 1970s in the Lemaire<sup>3</sup> procedure using a strip of the iliotibial band (ITB), as described in the French literature in 1967. In 1976, Macintosh<sup>4</sup> described the use of an ITB loop behind the lateral intermuscular septum. Also in 1976, Hughston *et al*<sup>5</sup> identified the middle third lateral capsular ligament attached proximally to the lateral epicondyle and distally to the tibial joint margin. They reported that sectioning this lateral capsular ligament resulted in a major increase of anterolateral rotatory instability.<sup>5</sup> In 1978, Losee *et al*<sup>6</sup> also using the ITB, described use of a tunnel created at the femoral lateral collateral ligament (LCL) attachment, exiting at the level of the lateral gastrocnemius tendon.

From these initial reports, the concept was then embellished by several 'follower' papers in the late 1970s and early 1980s demonstrating *Inflation*. In 1979, Norwood *et al*<sup>7</sup> analysed 36 patients with anterolateral rotatory instability. They reported

that isolated ACL injury was only present in four patients, while concomitant lateral structure injury (from lateral capsule to ilio-tibial tract) was present in 26 patients. In 1979, Ellison *et al*<sup>8</sup> described ACL reconstruction associated with an osteotomy of Gerdy's tubercle. In 1983, Andrews *et al*<sup>9</sup> described an anterolateral 'mini-reconstruction' by advancing the ITB. In 1986, Zarins and Rowe<sup>10</sup> reported a combined anterolateral capsule and ACL reconstruction using the ITB and the semitendinosus tendon. In 1986, Terry *et al*<sup>11</sup> in an anatomical study described the detailed anatomy of the capsulo-osseous layer of the ITB tract. In 1987, Lerat *et al*<sup>12</sup> reported a combined anterolateral capsule and ACL reconstruction using the lateral third of the patellar tendon and a strip of the quadriceps tendon. In 1987, Irvine *et al*<sup>13</sup> presented a detailed anatomical study of the anterior band of the LCL.

During the late 1980s and early 1990s, *Disillusion* became manifest as the initial concept did not appear to withstand the test of time. During this period there were a growing number of reports suggesting that extra-articular tenodesis techniques resulted in failure, particularly when performed as an isolated procedure. In 1994, Neyret *et al*<sup>14</sup> reported failures using the isolated Lemaire technique. Reports from the early 1990s did not show any clear advantage of combined procedures over isolated intra-articular reconstruction.<sup>15 16</sup> However, around 1990 it was shown that extra-articular lateral tenodesis could decrease ACL graft loads, possibly reducing the rerupture risk.<sup>17 18</sup> In 1987 and 1991, Roth *et al*<sup>19</sup> and O'Brien *et al*<sup>16</sup> reported secondary lateral knee compartment degenerative changes following extra-articular ACL reconstruction using the ITB. In 2011 Dodds *et al*<sup>20</sup> reported that extra-articular tenodesis alone did not restore normal kinematics in the presence of intra-articular ACL deficiency.

The *Eclipse* of this early extra-articular ACL repair procedure began in the early 1990s and continued through 2012 with the onset of exclusively intra-articular surgical procedures with the arthroscope entering operating rooms. Was it primarily the arthroscope, for example, the pressure to perform the entire surgery arthroscopically that threw the extra-articular anterolateral capsule reinforcement overboard?

The *Rebirth* of extra-articular anterolateral knee capsule augmentation started in 2012 and is ongoing. There has been

a rediscovery of the essential anatomy of this region with ‘landmark’ publications in 2012 including that of Vincent *et al*<sup>21</sup> which reported that anterolateral ligament (ALL) fibres merge with the lateral meniscus and Tanaka *et al*<sup>22</sup> which reported that the ALL is only a part of the anterolateral capsulo-ligamentous complex. In 2013, Claes *et al*<sup>23</sup> reported that the ALL inserts between Gerdy’s tubercle and the fibular head in addition to describing meniscotibial and menisiofemoral bundles. In 2016, Kittl *et al*<sup>24</sup> reported that the capsulo-osseous ITB layer provided a major knee rotatory stability function. Others have described the femoral ALL attachment as being somewhat variable, inserting either posteroproximally or anterodistally to the femoral origin of the LCL.<sup>23 25</sup>

The rapid adoption of new ‘anatomic ALL reconstruction’ surgical techniques suggests the *Inflation* phenomenon. The literature supports this with the work of Helito *et al*<sup>26</sup> and Smith *et al*<sup>27</sup> in 2015, and Sonnery-Cottet *et al*<sup>28</sup> and Wagih and Elguindy<sup>29</sup> in 2016. At this point in time new ALL reconstruction techniques are being adopted without having ever been studied in a biomechanics laboratory. To date, no clinical trials have directly compared ALL reconstruction with lateral extra-articular tenodesis procedures.<sup>30</sup> Biomechanical studies suggest that the ITB might be the most important restraint to internal rotation and that the ALL is of little importance.<sup>24</sup>

### ACL repair

We identified 2533 citations (figure 2).

*Hope* in the form of successful ACL repair initially began in the late 1930s and continued through the 1960s. Palmer in 1938<sup>31</sup> and O’Donoghue<sup>32</sup> in 1950 advocated ACL repair early following injury when it was possible to restore anatomical conditions. Many ‘followers’ embellished the initial concept contributing to *Inflation* during the 1970s and 1980s. These publications led to open primary ACL repair becoming the preferred technique for the treatment of ACL injuries over this period with good short-term results. The reader is referred to the works of England<sup>33</sup> and Feagin and Curl<sup>34</sup> in 1976, Macintosh in 1976–1977,<sup>4 35</sup> Marshall *et al*<sup>36</sup> in 1979, Lysholm *et al*<sup>37</sup>

in 1982, Warren<sup>38</sup> in 1983, Odensten *et al*<sup>39</sup> in 1985, Weaver *et al*<sup>40</sup> in 1985 and Sherman and Bonamo<sup>41</sup> in 1988.

In the late 1980s and early 1990s *Disillusion* with primary ACL repair set in with reports demonstrating that repair using the techniques of the day did not stand the test of time. Follow-up studies of open repair at mid-term to long-term demonstrated concerning failure rates and high postoperative morbidity (pain, stiffness and instability). The reader is referred to the works of Engebretsen *et al*<sup>42</sup> in 1989, Feagin and Curl<sup>43 44</sup> in 1990 and 1996 (reporting rerupture rates of >50% at 5 years), Kaplan *et al*<sup>45</sup> in 1990 and Sherman *et al*<sup>46</sup> in 1991 who reported that mid-substance ACL tears had poorer results than proximal tears.

The *Eclipse* of primary ACL repair continued through the 1990s through 2013. This abandonment largely occurred because several prospective randomised trials favoured ACL reconstruction to repair<sup>17 47 48</sup> and arthroscopic surgery had largely replaced open ACL repair methods. Additionally, ACL reconstruction could be more easily scheduled in contrast to ACL repair which needed to be performed acutely to maintain anatomical characteristics. Likewise, the rehabilitation protocols of the day focused solely on ACL reconstruction. These factors contributed to leave ACL repair behind with many unanswered questions regarding its true potential.

From 2013 to the present we have seen a *Rebirth* of interest in primary ACL repair, particularly with use of some form of internal support to facilitate the healing process. Factors associated with this renewed interest include preservation of native ACL proprioceptors that drive the neuromuscular control of dynamic knee stability, native anatomy restoration, developing support for orthobiological tissue healing factors, less surgical morbidity and preservation of other knee joint region tissues for revision purposes if necessary. With this *Rebirth* attempts are being made to improve outcomes and reduce rerupture rates compared with historical repair and even reconstruction procedures. Innovative surgeons and industry are promoting new arthroscopic surgical techniques and instrumentation. Readers are referred to the landmark work of Kohl *et al*<sup>49</sup> who described a dynamic intra-ligamentary stabilisation technique in 2013, Biercevicz *et al*<sup>50</sup>

Results per 100,000 citations in PubMed

proportion for each search by year, 1975 to 2020

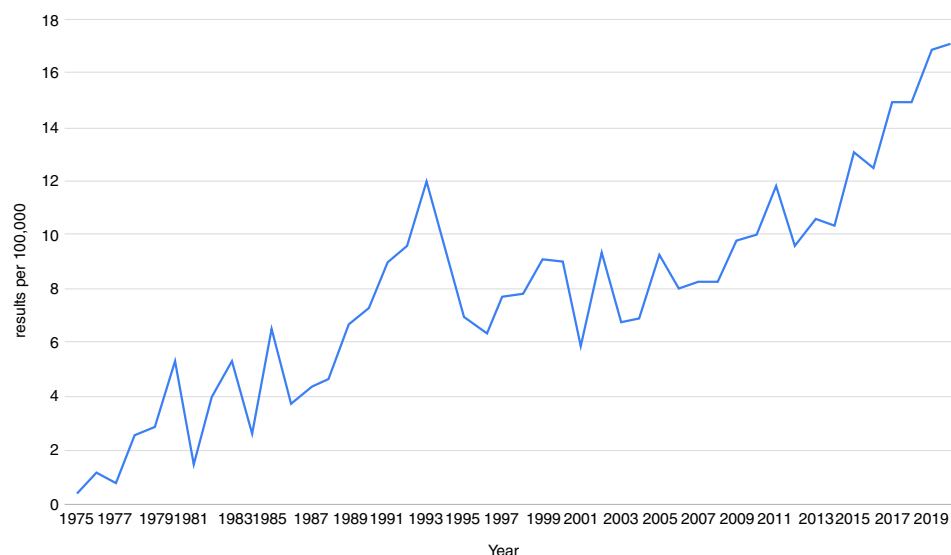
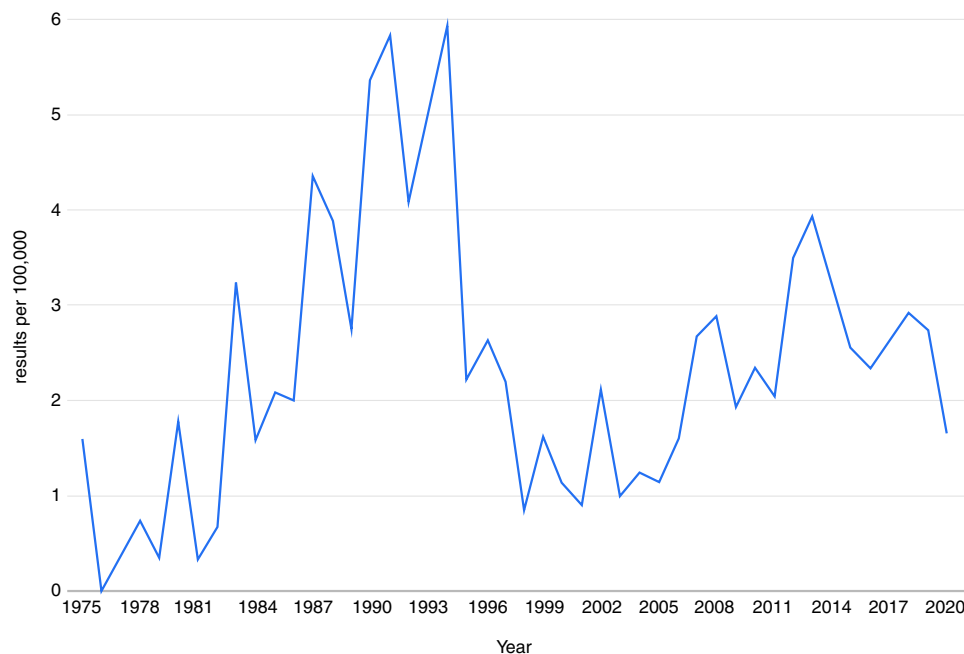


Figure 2 Temporal trends in publications on ACL repair.

**Results per 100,000 citations in PubMed**  
proportion for each search by year, 1975 to 2020



**Figure 3** Temporal trends in publications on prosthetic devices for ACL reconstruction.

who described internal brace augmentation in 2015, Murray *et al*<sup>51</sup> and Kiapour *et al*<sup>52</sup> who described the bridge-enhanced ACL repair technique in 2016, and Achtnich *et al*<sup>53</sup> who described ACL repair suture fixation in 2016. In reviewing the older literature, Sherman *et al*<sup>46</sup> and van der List *et al*<sup>54</sup> reported excellent outcomes for patients with proximal ACL tears. Additionally, higher resolution MRI can now provide more accurate tear location and type delineation, better identifying patients who might benefit from primary ACL repair. Recent systematic reviews<sup>55–57</sup> suggest that primary ACL repair may be efficacious for younger patients with skeletal immaturity who present acutely with proximal tears. However, the overall complication/reoperation rate (15%) in addition to more common passive knee range of motion impairments suggest that its general use remains inferior to ACL reconstruction. More clinical documentation is needed before widely adopting these techniques. National multicentre registries need to be established to closely follow these patients.

#### Prosthetic devices for ACL reconstruction

We identified 647 citations (figure 3).

During the early part of the twentieth century *Hope* abounded for the development of a prosthetic ACL with goals of implanting a strong, ‘off the shelf’ construct that allowed rapid rehabilitation and early return to activities. In 1907, Lange described the cases of four patients who received intra-articular artificial silk ACLs in conjunction with extra-articular semitendinosus and semimembranosus tendon augmentation.<sup>58 59</sup> In 1918, Alwyn Smith<sup>60</sup> reported using silk material to repair the ACL, which at 3 months resulted in synovitis that necessitated its removal from the joint. In 1949, Rutherford<sup>61</sup> reported failure for ACL reconstruction using Supramid, a polyamide derivative. In 1979, Woods *et al*<sup>62</sup> and others reported breakage at just over 1 year postsurgery for ACL reconstruction performed with Proplast: polytetrafluoroethylene (PTFE) with embedded carbon or aluminium oxide fibres. In treating patients with multiply operated, unstable

knees, Ahlfield *et al*<sup>63</sup> reported superior objective and subjective results among patients who received the expanded PTFE prosthesis compared with the conventional Proplast device at 24 months postsurgery.

The underachieved *Hope* of the early twentieth century led to the *Inflation* of the 1980s with a progression of biomaterials with synthetics rapidly growing in popularity for ACL reconstruction in three main forms: grafts that enabled tissue vascularisation and maturation, permanent prosthetic replacement without soft tissue ingrowth, and augmentation in the form of a stent or graft wrap for protection through the revascularisation and tissue ingrowth periods. Following this, in somewhat rapid succession, in 1978, Jenkins<sup>64</sup> reported on carbon fibre based ACL graft development to serve as a temporary implant promoting fibroblast ingrowth and collagen production. To reduce carbon wear particle development this construct was modified by Alexander *et al*<sup>65</sup> in 1983 to include a polylactic acid and polycaprolactone coating. Strover<sup>66</sup> later described the Activated Biological Composite prosthetic (ABC, Surgicraft, Redditch, UK) which blended carbon (for fibrogenesis) and polyester (for durability) fibres. In 1980, Kennedy *et al*<sup>67 68</sup> introduced a band-like polypropylene braid, the ligament augmentation device (LAD, 3M, St Paul, Minnesota, USA), to protect the vulnerable autologous graft during remodelling. The LAD was implanted using the Macintosh/Marshall ACL reconstruction technique. In 1985 the Gore-Tex prosthesis made of looped PTFE was developed by Gore and associates, demonstrating an ultimate tensile strength three times that of the human ACL.<sup>69</sup> Following a similar principle of graft augmentation, Mansat<sup>70</sup> described the Proflex ligament (Protek, Bern, Switzerland), a polyester stent used to reinforce a patellar tendon autograft, with the transplant fixed in a femoral tunnel and the artificial ligament attached over the top. Inspired by previous vascular implant success, the polyester strip based Stryker Dacron ligament prosthesis (Stryker, Kalamazoo, Michigan, USA) was developed in 1988.<sup>71</sup> In 1992, based

on polyester composite meshes, the Leeds-Keio prosthesis was developed (Xiros, formerly Neoligaments, Leeds, England) to serve as a soft tissue ingrowth scaffold. With this device some have reported neoligamentous tissue ingrowth<sup>72</sup> while others have found it to behave as a permanent prosthesis.<sup>73</sup>

Because of poor outcomes and high mid-term and long-term complication rates,<sup>74–75</sup> *Disillusion* for prosthetic ACL development occurred in the 1990s. Prosthetic implant use was associated with intra-articular debris generation from osseous surface abrasion, reactive synovitis and effusion, mechanical fibre fatigue with instability and failure, osteolysis, and premature osteoarthritis development. Chronic synovitis predisposed to infection. Issues such as these were identified in 1988 for the Gore-Tex prosthesis,<sup>76–79</sup> in 1991 for the Leeds-Keio prosthesis<sup>73 80 81</sup> and in 1992 for the Stryker Dacron ligament prosthesis.<sup>82–84</sup> In 1992, synovitis characterised by foreign body giant cells and macrophages in the surrounding tissue,<sup>85</sup> a weak graft interface and autogenous tissue stress-shielding were identified with the LAD.<sup>86</sup> A randomised controlled trial failed to reveal any benefit for LAD use.<sup>87</sup> From 1993 onwards, similar issues were identified for the ABC prosthesis.<sup>88</sup> Poor results were confirmed in a systematic review published in 2015<sup>75</sup> and in a long-term follow-up study published in 2010.<sup>89</sup> The *Eclipse* of ACL prosthesis development occurred in the 1990s as poor long-term results suggested that they were no longer suitable for ACL reconstruction.

Associated with promotions to achieve more rapid and spectacular mobility and strength by avoiding donor site morbidity, the *Rebirth* of ACL prosthetic devices occurred in the 2000s. In 2000 the Ligament Advanced Reinforcement System prosthesis was developed in France. It consists of polyethylene terephthalate (PET) fibres with an intraosseous component to promote bony ingrowth and an intra-articular part with fibres designed to be more fatigue and wear resistant to natural ligamentous torsion. Lavoie *et al*<sup>90</sup> first reported its clinical use. Since this time there have been conflicting results reported<sup>91 92</sup> followed by various clinical applications, including posterior cruciate ligament reconstruction,<sup>93</sup> multiligament reconstruction following knee dislocation,<sup>94</sup> acromioclavicular joint separation<sup>95</sup> and hip abductor tendon repair.<sup>96</sup> At 6 years postsurgery failure rates of 33% have been reported for ACL reconstruction.<sup>92</sup> In 2006, with the addition of a radiofrequency procedure a second generation polyester composite Leeds-Keio prosthesis was developed to provide better tissue ingrowth capability.<sup>97</sup> Ongoing research in China on PET fibres is studying how prosthesis ligamentisation can be enhanced<sup>98</sup> to improve biocompatibility, thereby promoting better cell adhesion/proliferation and osteointegration. Hydroxyapatite<sup>99</sup> and silk fibroin<sup>100 101</sup> coatings are being studied for enhanced ligamentisation. Currently, the primary obstacle to successful prosthetic ACL reconstruction is longevity, as autologous graft sources provide more durable replacements. Synthetic ligaments with no abrasion, no immune reactions and that enable significant tissue ingrowth have not been developed.

### Study limitations

This study has several important limitations. The study methods that were used quantitatively analysed specific topics as described a priori. A citation analysis was performed based on study titles and abstract reviews. However, content analysis of each study was not performed and there were no exclusion criteria. Therefore, even non-clinical and basic science studies on the selected topics were included. Also, no distinction was made between

original articles and review papers. Also, journal impact factor of the articles that contributed to this study were not assessed. Use of the *Thomson Reuters Journal Citation Report* which is commonly used in bibliometric analysis would have enabled selection of articles that were published solely in higher impact journals. This would have enabled concurrent assessment of study quality in addition to volume and rate of publication. The studies that contributed to this analysis were found exclusively using the PubMed search engine to review the MEDLINE database. Other databases such as Embase and Web of Science were not included. The MEDLINE database cites studies from the US National Library of Medicine at the National Institutes of Health. The USA is the largest single nation contributor to scientific research, however, studies from other databases may have been omitted. The statistical methodology that was used only represented descriptive global research trend analysis based on selected topics. It has shown a cyclic nature of publications only. It remains unclear how much this research has affected current clinical practices over the years. Also, the primary author solely screened each study. Therefore, potential exists for selection bias risk. Lastly, the trend timing figures are based on publication date. Actual research performance and report development likely occurred 6–12 months prior to publication.

### Lessons learnt

Rather than rushing to a new surgical technique, history has repeatedly shown that knee surgeons and orthopaedic surgeons in general should adopt a more systematic stepwise approach to investigating content related to innovative knee surgical procedures. This approach should give ample respect and a more humble attitude to the need for understanding surgical anatomy and histology, biomechanical studies and well-designed clinical trials.

Three general tendencies were observed in figure graphics: (1) Initial hope-inflation and rebirth trend peaks occurred after a minimum of 20 years between phases; (2) The initial hope-inflation and rebirth phase trend peak interval for anterolateral knee instability seems to be approximately 35 years; and (3) Rebirth trend peak slope trajectories for each topic seemed to display more rapid and stronger rise times than the initial trend peak slope trajectories. As the literature review spans only 45 years, it is important to emphasise that these findings solely represent trends of interest, and not firm, evidence-based conclusions. We propose that this observation warrants further study. What combination of events catalysed these rebirth trajectories? Did this occur because key research evidence had better established a more solid path to renewed topic interest?

Given the limitations of the day many of these ‘old ideas’ may have been underestimated or misunderstood at first glance leading to their initial *Eclipse*. This does not mean that they could not be revisited and improved on. Innovative thoughts and original discoveries often arise from surgeons outside of academic centres. Many times, these ‘doers and true thinkers’ were orthopaedic surgeons and sports medicine practitioners such as Lemaire,<sup>3</sup> Macintosh,<sup>4</sup> and Losee<sup>6</sup> who learnt by doing, spending long days in the operating theatre. They meticulously studied and learnt from each surgical case taking notes, creating drawings and taking photographs. From this they discovered unusual or unique anatomical situations and confirmed new soft tissue trauma pathoanatomy patterns and healing responses in the process.

Remembering is important! To better capture how historical surgical procedures and techniques might be of benefit today

given the resources available in the world we live in, it may be beneficial for young surgeons to review the work of previous generation surgeons and scientists through more contemporary eyes. We should also better identify when a particular surgical procedure has repeatedly failed despite ample amounts of hope and enthusiasm. In cases such as these we need to be more vigilant to ensure that young knee surgeons do not get seduced again by ‘new discoveries’ that have proven time and time again to fail. As George Santayana, a Spanish-born American author and philosopher of the late nineteenth and early twentieth centuries stated, ‘Those who cannot remember the past are condemned to repeat it’.<sup>102</sup> Studying history is necessary to avoid repeating past mistakes. To this we only add that it may suffice to reference key historical works, and to revisit surgical procedures in the morgue and in laboratories with fresh, contemporary eyes.

## CONCLUSIONS

Based on this analysis we recommend that knee surgeons become more aware of the lessons of history. Important lessons can be learnt from both the past successes and failures of our predecessors. If we do not learn from their failures, we will be likely to repeat them, placing patients at an unjustified risk. From past successes we can build on previous good ideas and important discoveries that have shown themselves to be tried and true over time. The cycle phenomenon that was observed by the senior author (RPJ) suggests that knee surgeons need to better balance early enthusiasm and hope for innovative surgical practice efficacy with the guidance of scientific rigour derived evidence and history. History suggests that when past surgical practices have failed, their ‘rediscovery’ was consistently associated with a better understanding of the vital interdependence between ACL anatomy, tissue composition, biomechanics and healing processes. Resar stated that healthcare clinicians successfully apply proven medical evidence less than 80% of the time. Knee surgeons should remember to approach all innovations with care and patience, as the effects of good and bad surgical practices may take years to become manifest. This ‘wait and see’ approach blended with the systematic acquisition of scientific evidence and reflective clinical practice might be the best path to improving patient outcomes.

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