EPiC Series in Health Sciences

Volume 5, 2022, Pages 185–189

Proceedings of The 20th Annual Meeting of the International Society for Computer Assisted Orthopaedic Surgery

Computer and Robotic Assisted Orthopaedic Knee Arthroplasty Surgery
Did CAOS technologies have an impact on the mainstream principles and concepts in the orthopaedic knee forum?
A case study on alignment and balancing for TKA.

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1 Introduction

Computer technology is ubiquitous and relied upon in virtually all professional activities. Confounding this is orthopaedic surgery where less than 5% of surgeons in the USA, Europe and Asia are using computer-assisted technologies routinely [1].

These are all used to, not only assist the surgeon in augmenting surgical procedures, but also to provide hitherto unavailable quantitative data not seen and sometimes not known that could help the surgeon fine tune the surgery to an individual profile.[2]

One of the most commonly discussed issues with knee replacement and CAOS (computer assisted orthopaedic surgery) is the impact that accuracy of computer-assisted surgery has had on the outcomes of surgical procedures.[3]

In this paper we delved into the impact CAOS has had on the general “orthopaedic forum” in approaching diagnostic and therapeutic guidelines, focussing on the discussion on knee

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replacement surgeries using alignment and soft tissue management as a case study.

2 Materials and Methods

We did a literature query dividing alignment papers by those including navigation and those excluding navigation using pubmed - ((((knee) AND (arthroplasty OR replacement)) AND (alignment OR balance OR balancing OR "soft-tissue"))) AND (navigation OR CAS OR "computer aided" OR "computer assisted") pubmed - ((((knee) AND (arthroplasty OR replacement)) AND (alignment OR balance OR balancing OR "soft-tissue"))) NOT (navigation OR CAS OR "computer aided" OR "computer assisted").

Then we divided the number of papers published on knee alignment and TKA (Total Knee Alignment) between 1976 and 2016 into those related to CAOS and those which are not.

Finally, we matched these data to four clusters of knee innovation papers as described in our previous review. [3]

3 Results

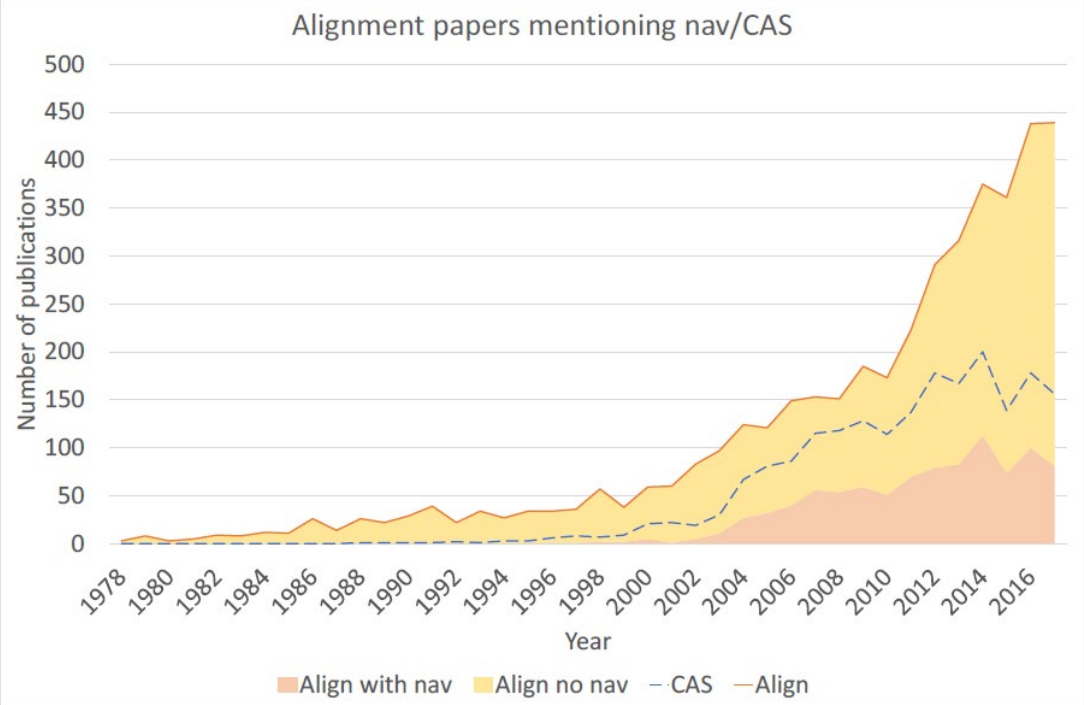

Figure 1: Query dividing alignment papers by those including nav and those excluding nav pubmed - ((((knee) AND (arthroplasty OR replacement)) AND (alignment OR balance OR balancing OR "softtissue"))) AND (navigation OR CAS OR "computer aided" OR "computer assisted") pubmed - ((((knee) AND (arthroplasty OR replacement)) AND (alignment OR balance

OR balancing OR "soft-tissue"))) NOT (navigation OR CAS OR "computer aided" OR "computer assisted"). X

Between 2001 and 2004, the number of publications regarding knee navigation multiplied by 20 mainly focused on this topic of alignment. Comparing the number of publications between navigation versus non-navigation, there is a parallel trend between 2001 and 2010 while afterwards the number of knee navigation papers declined either because there was no need to demonstrate the benefits anymore or because a drop in navigation use. However, the number of publications related to the topic of knee alignment grew significantly to reach four times more than the number of papers on similar topic with navigation by 2016.

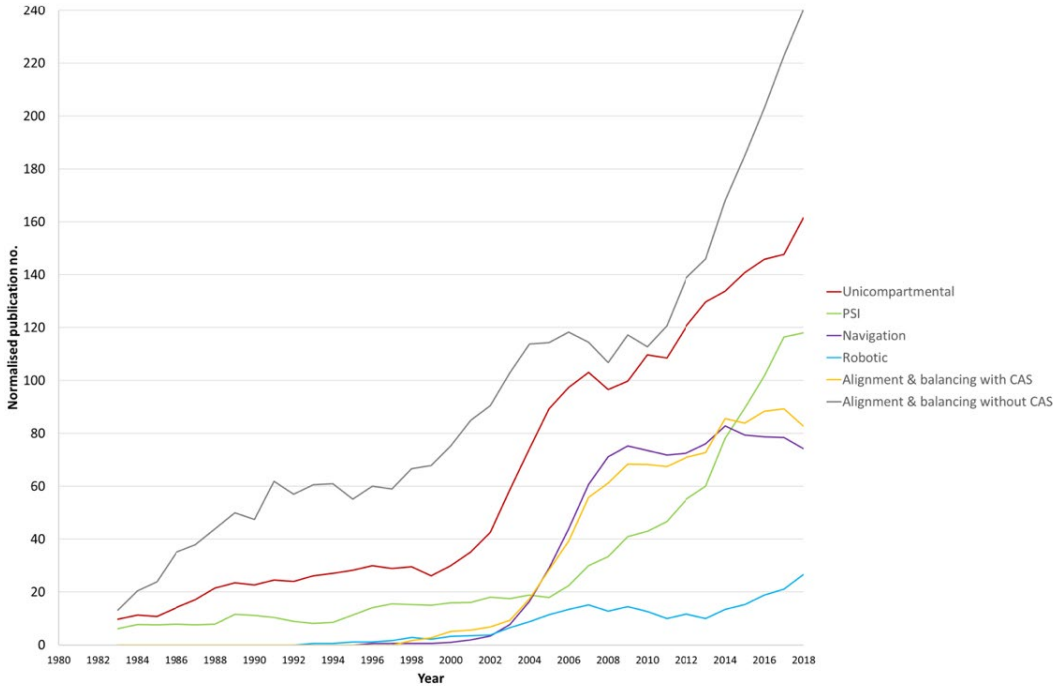

Figure 2: Relationship between alignment and balancing publications with CAOS (yellow) and without (purple). The two lines are almost overlapping until 2014 which coincidently coincide with the increase of publications related to robotics but also the spread so-called kinematic alignment concept.

Figure 2 showed an almost identical trend between the number of knee navigation papers and the number of papers related to knee alignment and balancing. From 2004 until 2008, the number of publications related to knee navigation rocketed during this period showing solid evidence of interest in the technology but also genuine vigilance from orthopaedic community in order to avoid worrying past experiences.

By 2008, the number of publications for navigation declined whereas they increased for PSI. After 2014, while the number of publications increased massively for PSI, navigation and robotic publication numbers went to opposite direction in favour of the later to the former.

The overall number of publications related to alignment and balancing in conventional knee

replacement follows very closely the initial increase line from navigation until 2008. They even follow a temporary depression in publication number between 2008 and 2010 to escape the navigation curve in following the increasing number of publications for PSI and robotic knee surgery.

4 Discussion

The original claims for using CAOS, and specifically navigation, was that the technology would be more accurate and precise than conventional surgery, enhancing the threedimensional position and alignment and maybe balancing of joint replacements [3].

From 2003, onwards a wave of publications supported by the large corporations, promoted Minimally Invasive Surgery (MIS) for knee arthroplasty which created a temporary diversion from the adoption of CAOS technology. However, alignment and balancing criteria after TKA remained a major outcome assessment factor in publications which suggested to a few authors to combine MIS and navigation. [4]

Between 2004 and 2006, the industry felt that investing more into PSI may, on the one hand, solve the ergonomic issues surgeons complained about but, on the other hand, may solve their economic problems related to navigation. Once again alignment and balancing criteria were used as primary or secondary outcomes for studies.

Following initial experiences with PSI and the combination of a lack of strong evidence of functional improvements with CAOS as well as controversies around alignment in knee arthroplasty, the so-called kinematic alignments became more popular after 2014. This may have suggested that actually accuracy and precision in knee replacement may not be as paramount as we thought [5].

Back to 2010, the orthopaedic industry had invested a lot in robotic-assisted technology despite unsuccessful past market introduction and less in navigation certainly to offset implant price reduction and the lack of instalments for the costly surgical trays/instrumentations. Selling at a very high price, robots became suddenly appealing to the industry but on the other hand remained an obvious and significant restraining factor of use of this technology due to the high capital cost for users.

Mako® attracted Stryker®, one of the leading orthopaedic majors in the world who acquired Mako® for $1.6 billion between 2012 and 2013 launching the “robot war” between competitors. Smith & Nephew bought the Navio®/BlueBelt/CORI Technology for $275 million in 2016, Zimmer bought the ROSA® robotic system for at least $132 million, and more recently Johnson & Johnson invested in a new robot named Velys® for an unclosed amount, while the first active Robodoc® system product of the Think® company is still in use.

Once again alignment accuracy and implant position precision were foremost criteria factors of technology assessment.

According to our analysis CAOS has had a chief impact on the mainstream principles and concepts in the orthopaedic knee forum.

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