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Original Research Article

Needle gauge and patient pain in steroid injection of the knee: a prospective randomized controlled trial

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ABSTRACT

Background: Intra-articular corticosteroid injection (IACI) is a common conservative treatment modality for knee osteoarthritis (OA) but can cause procedural discomfort. Needle gauge is a modifiable factor that may influence patient pain perception, though evidence remains limited. This study compared 18- versus 22-gauge needles in knee IACIs.
Methods: The authors performed a single-blinded, prospective, randomized controlled trial at a public teaching hospital (San Joaquin General Hospital, in French Camp, CA) from May 10, 2023 to October 16, 2024. Adults with primary knee OA indicated for corticosteroid injection were randomized to receive injection with either an 18-gauge or 22-gauge needle. All injections were performed via the superolateral approach using triamcinolone acetonide and lidocaine. Pain scores were measured using a visual analogue scale (VAS). Secondary outcomes included anticipated pain, nervousness, and satisfaction.
Results: Twenty-six patients were randomized (14 in the 18-gauge group, 12 in the 22-gauge group). Median injection pain was similar between groups (median 2.5 vs 2.5, p=0.71). Post-injection pain was lower in the 18-gauge group (median 1.5 vs 3.5, p=0.21), but not statistically significant. Pre-injection nervousness correlated with both injection pain (ρ=0.50, p=0.011) and post-injection pain (ρ=0.55, p=0.004).
Conclusions: Needle gauge did not significantly affect pain or satisfaction during knee IACIs. Psychosocial factors appear to play a greater role in pain perception than needle size.

Keywords: Intra-articular, Corticosteroid injections, 22-gauge, 18-gauge, Patient pain, Knee osteoarthritis

INTRODUCTION

Osteoarthritis (OA) of the knee is a highly prevalent condition of the musculoskeletal system--an estimated 27 million individuals in the US alone suffer from this pathology, with an increased incidence correlating with increased age and obesity level.[1] More recent literature has suggested a general OA incidence trend worldwide of over 500 million cases, which would place OA as the 15th leading cause of overall disability.[2] The knee joint is the most frequently implicated in OA disease processes, and is a major contributor to overall patient morbidity and impaired functional status.[3] Pathophysiologically, the larger mechanical load imposed by larger body habitus works synchronously with systemic effects associated with obesity/metabolic syndrome-induced inflammation-- the cumulative effect is not only damage the knee's articular cartilage, but also increase stress loads on the synovium, subchondral bone, ligaments and surrounding musculature.[3]

At the cellular level, the upregulation of pro-inflammatory cytokines associated with obesity/metabolic syndrome damages the structural integrity of high load joints like the knee. The result is increased levels of adipokines in the articular cartilage, proteolytic aggrecanases and matrix

metalloproteinases, free reactive oxygen species (ROS), and fatty acids induced by systemic dyslipidemia.[3] Like many other pathologies, OA is a multifactorial disease. Gender is a relevant factor with higher incidences in women as compared to men, in addition to the aforementioned significant risk factors of age and obesity.[4,5] In a large cohort study including a patient number n=31,162 all ≥20 years of age, when compared to the non-OA group, the OA group showed significantly higher proportions of central obesity, Klemera-Doubala method age (KDM-age), KDM-age advance, phenotypic age (PhenoAge), and PhenoAge advance.[6] These statistics and pathophysiological mechanisms considered in whole indicate that knee OA is a significant contributor to the global disease burden, with overall incidence only predicted to escalate to the tune of 74.9% by 2050.[7] As such, the treatment of knee OA is a topic with clear socioeconomic and global health implications.

IACIs for knee OA provides short-term pain relief aimed to improve functionality and permit rehabilitation.[8] According to the American Academy of Orthopedic Surgeons clinical practice guidelines, IACIs are a moderate recommendation in the treatment of symptomatic knee OA, providing patients reasonable, short-term pain relief.[9] While the therapeutic benefits of corticosteroids are well-documented, the procedural aspects of injection have yet to be as well elucidated in the literature.[8] These include factors such as approach, injectate composition, and needle gauge. Multiple studies have provided ambiguous results due to variable practice patterns across providers, falling short of setting any clear standard regarding needle size or pain mitigation strategies in steroid injections for knee OA.[10,11] Minimizing procedural discomfort is particularly important given that steroid injection therapy for knee OA is often a repetitive measure. Reducing patient pain and anxiety is critical for maintaining patient adherence in following interventions.[12]

Variations in injection may include the injectate. Triamcinolone, dexamethasone, methylprednisone and betamethasone are all commonly employed formulations. Efforts to identify the optimal corticosteroid molecule and dose have been sparse, and largely fall upon provider preference.[13] Additionally, the injection approach itself presents another item of variation. The superolateral approach has been reported as the most accurate site for injection, with a pooled accuracy of 91% in one meta-analysis.[14] Other authors have suggested no one approach to be superior, and physician preference and experience may be more important.[15] Needle gauge is a modifiable procedural variable that has been examined to some degree. In the existing literature relevant to knee OA injections, the findings are mixed. Larger gauge needles (18 gauge) may be preferable in their ability to deliver higher viscosity formulations like triamcinolone acetonide. One study examining IACIs did find 22-gauge and larger needles were more painful than 25-gauge needles in the absence of ethyl chloride spray-this effect was modified to non-significance with the introduction of ethyl chloride.[16] To date, the literature surrounding the effect of needle gauge specifically on patient perception of pain in corticosteroid to the knee is limited. The purpose of this study is to compare 18-gauge and 22-gauge needles with regard to patient perception of pain in the setting of corticosteroid injection to the knee for OA.

METHODS

This single-blinded, prospective, single-center, randomized controlled study was conducted in the setting of an outpatient orthopedic clinic at a public teaching hospital (San Joaquin General Hospital in French Camp, CA). The study protocol was approved by an institutional review board, and the enrollment period spanned from May 10, 2023 to October 16, 2024.

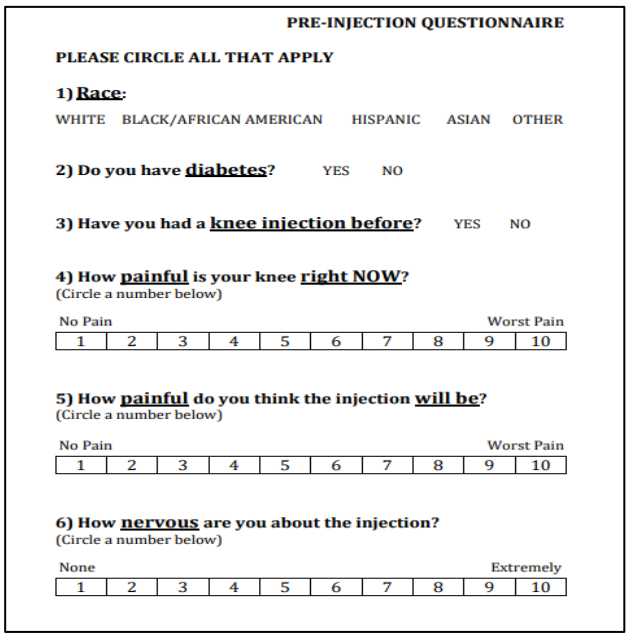
Adults ≥18 years of age presenting with principal visit diagnosis of primary OA of the knee and indicated for corticosteroid injection to the knee were screened sequentially for inclusion in the study. Exclusion criteria consisted of age under 18, incarcerated status, non-native English speaking, illiteracy, allergy to corticosteroid or local anesthetic, active infection of the skin overlying the planned injection site or infection of deep structures, previous corticosteroid injection within 3 months, inability to fill out the questionnaire, and declination to participate. Written, informed consent was obtained from each patient prior to enrollment.

Prior to injection, data collected included demographic variables of age, sex, race, diabetes status, height, weight, and BMI. Further pre-injection variables collected included pre-injection pain and anticipated injection pain. Pain scores were collected on a VAS. Pre-injection nervousness was collected on a 10 point Likert scale ranging from 1, “not nervous”, to 10, "extremely nervous”. Patients were also asked if they had previously received a corticosteroid injection. One minute following injection, patients were administered the post-injection survey.

A power analysis was conducted based on the results by Tubach and colleagues.[17] We determined a minimum sample size of 24 patients (at least 12 per group) was necessary to meet the VAS minimal clinically important difference (MCID) of 2.0 with a standard deviation of 1.6. Randomization was conducted in advance utilizing a random number generator. Thirty sequential folders were created, labeled “group A” or “group B”.

After patients were enrolled, patients were randomized to group A (18-gauge needle) or group B (22-gauge needle) by selection of the next-in-sequence pre-randomized folder. A random number generator was utilized to randomize the folders. The authors proceeded to collect data until there were 12 patients in each group, resulting in the final n=26 patients. Pre-injection surveys were administered after informed consent was obtained, and patients were allowed time alone to complete the survey.

All injections were performed by an orthopedic surgery resident. All injections were performed with the patient in the supine position through the superolateral approach. Skin was aseptically prepared with an alcohol swab prior to injection. Injections were performed with an 18 gauge needle and a 22-gauge needle for patients randomized to group A and group B, respectively. Patients were not permitted to see the needle at any time during the procedure. Injections were 5 cc in volume, consisting of a 1:4 combination of triamcinolone acetonide 40 mg/ml (1 cc) and 1% plain lidocaine (4 cc). Following injection, patients were then administered the post-injection survey (Figures 1 and 2).



PRE-INJECTION QUESTIONNAIRE

PLEASE CIRCLE ALL THAT APPLY

1) Race:

WHITE BLACK/AFRICAN AMERICAN HISPANIC ASIAN OTHER

2) Do you have diabetes? YES NO

3) Have you had a knee injection before? YES NO

4) How painful is your knee right NOW?
(Circle a number below)

No Pain									Worst Pain
1	2	3	4	5	6	7	8	9	10

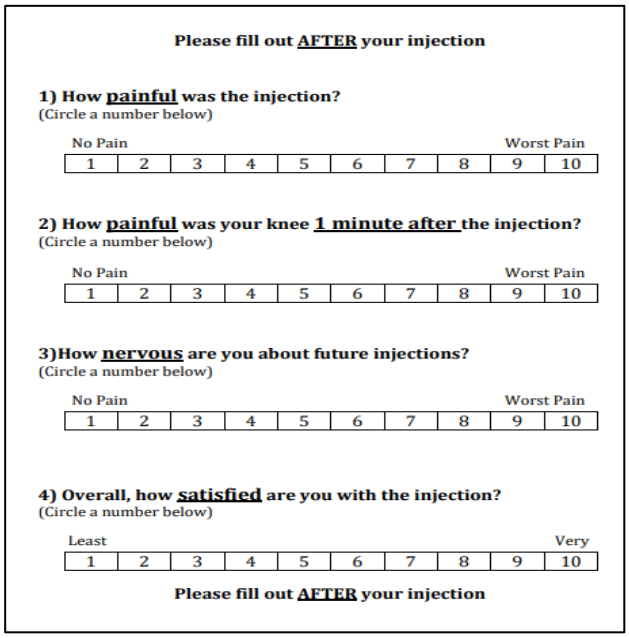
5) How painful do you think the injection will be?
(Circle a number below)

No Pain									Worst Pain
1	2	3	4	5	6	7	8	9	10

6) How nervous are you about the injection?
(Circle a number below)

None									Extremely
1	2	3	4	5	6	7	8	9	10

Figure 1: Pre-injection survey.



Please fill out AFTER your injection

1) How painful was the injection?
(Circle a number below)

No Pain									Worst Pain
1	2	3	4	5	6	7	8	9	10

2) How painful was your knee 1 minute after the injection?
(Circle a number below)

No Pain									Worst Pain
1	2	3	4	5	6	7	8	9	10

3)How nervous are you about future injections?
(Circle a number below)

No Pain									Worst Pain
1	2	3	4	5	6	7	8	9	10

4) Overall, how satisfied are you with the injection?
(Circle a number below)

Least									Very
1	2	3	4	5	6	7	8	9	10

Please fill out AFTER your injection

Figure 2: Post-injection survey.

Data analysis was conducted utilizing Python 3.11 with deployment of SciPy, NumPy, and Pandas packages.[18-21] Shapiro-Wilk tests were run on the collected VAS and Likert-style data to determine if the assumption of normality could be made. Statistical comparisons were made between groups utilizing Mann-Whitney U tests for non-normal continuous variables and Chi-Squared tests for categorical variables. Kruskal-Wallis test was utilized to compare different injectors and examine for injector-dependent effect. If less than five items were contained within a compared category, Fischer's exact test was utilized in lieu of chi-squared. Spearman correlation coefficients were calculated to determine correlations between nervousness and injection pain, between anticipated injection pain and injection pain, and between satisfaction and injection pain. The threshold of statistical significance was set as a $p \leq 0.05$.

RESULTS

Study cohort

Twenty-six patients met the inclusion criteria and were included in the study. Fourteen patients were randomized to the 18 gauge needle (Group A), and 12 patients were randomized to the 22 gauge needle (Group B). The median age of the cohort was 59 [IQR: 52.5-67.8]. Median BMI was 37.9 [IQR: 35.4-42.5]. Sixteen patients (61.5%) had previously received corticosteroid injections to the knee for their OA (n=9 in group A, n=7 in group B). There were no significant differences between the groups in regards to diabetes status, sex, race, age, BMI/prior injection experience ($p>0.05$) (Table 1).

Needle gauge and outcomes

No significant differences were found between needle gauges across all recorded patient pre and post-injection variables. Detailed reporting on pre-injection nervousness, pre-injection pain, anticipated injection pain, injection pain, post-injection pain, and patient satisfaction is provided in Table 2. Shapiro-Wilk test revealed non-normality of all pre and post-injection variables with the exception of anticipated injection pain.

Injection pain was similar across both groups, with a median of 2.5 [IQR: 2.0-5.8] in the 18 gauge group and a median of 2.5 [1.0-4.5] in the 22 gauge group. Patient satisfaction was also similar across both groups, with a median of 10.0 [8.2-10.0] in group A and a median of 9.5 [6.0-10.0] in B. Reported 1 minute post-injection pain was lower in the 18 gauge group with a median of 1.5 [1.0-3.8] versus the 22 gauge group with a median of 3.5 [1.0-5.2], but did not reach statistical significance ($p=0.21$). The change in pain from pre- to post-injection was greater in the 18 gauge group with a median of -5.5 [-6.8- -3.0] versus a median of -3.0 [-4.0- -2.0] in the 22 gauge group. This difference also did not reach statistical significance ($p=0.078$). The change in pain across both groups did reach the established VAS MCID of 2.0 points.

Table 1: Baseline characteristics.

Variables	Category	Group A	Group B	Overall	P value
Sex	Male	5 (36%)	6 (50%)	11 (42%)	0.4623 (Chi²)
	Female	9 (64%)	6 (50%)	15 (58%)	NaN
Diabetes	No	12 (86%)	6 (50%)	18 (69%)	0.0895 (Fisher)
	Yes	2 (14%)	6 (50%)	8 (31%)	NaN
Prior injection	No	5 (36%)	5 (42%)	10 (38%)	1.0000 (Fisher)
	Yes	9 (64%)	7 (58%)	16 (62%)	NaN
Laterality	Left	8 (57%)	5 (42%)	13 (50%)	0.4314 (Chi²)
	Right	6 (43%)	7 (58%)	13 (50%)	NaN
Race	Asian	2 (14%)	2 (17%)	4 (15%)	0.6800 (Chi²)
	Black	0 (0%)	1 (8%)	1 (4%)	NaN
	Hispanic	5 (36%)	4 (33%)	9 (35%)	NaN
	Other	1 (7%)	2 (17%)	3 (12%)	NaN
	White	6 (43%)	3 (25%)	9 (35%)	NaN
Age (in years)		55.0 [47.5-62.5]	62.5 [58.5-68.5]	59.0 [52.5-67.8]	0.1287 (U)
BMI (kg/m²)		38.6 [35.4-47.1]	37.9 [35.7-39.7]	37.9 [35.4-42.5]	0.4874 (U)

Table 2: Mann-Whitney U test results (Median [IQR]).

Variables	Group A	Group A median [IQR]	Group A mean (STD)	Group B	Group B median [IQR]	Group B mean (STD)	P value
Injection pain	14	2.5 [2.0-5.8]	3.9 (2.8)	12	2.5 [1.0-4.5]	3.6 (3.0)	0.7141
Post-injection pain	14	1.5 [1.0–3.8]	2.5 (2.2)	12	3.5 [1.0-5.2]	3.6 (2.4)	0.2074
Satisfaction	14	10.0 [8.2-10.0]	8.9 (1.8)	12	9.5 [6.0-10.0]	8.3 (2.2)	0.5092
Pre-injection pain	14	7.5 [6.2-8.0]	7.0 (2.3)	12	8.0 [5.0-8.0]	6.5 (2.3)	0.6122
Anticipated injection pain	14	6.0 [4.2-8.5]	6.0 (2.8)	12	5.0 [4.8-7.2]	5.6 (2.4)	0.6970
Pre-injection nervousness	14	4.5 [1.0-8.8]	5.0 (3.8)	11	3.0 [1.5-6.5]	4.4 (3.2)	0.7802
BMI (kg/m²)	14	38.6 [35.4-47.1]	41.3 (8.7)	12	37.9 [35.7-39.7]	37.2 (6.0)	0.4874
Δ pain	14	-5.5 [-6.8--3.0]	-4.6 (3.1)	12	-3.0 [-4.0--2.0]	-2.9 (1.6)	0.0776

Nervousness and pain

Spearman correlation tests revealed that the variable of nervousness demonstrates moderate positive correlation with both injection pain (ρ=0.50, p=0.011) and post-injection pain (ρ=0.55, p=0.004).

Anticipated and actual pain

Spearman correlation test demonstrated that anticipated injection pain correlated positively with both injection pain (ρ=0.56, p=0.003) and post-injection pain (ρ=0.41, p=0.038).

Satisfaction and pain

Spearman correlation test revealed that both injection pain and post-injection pain correlated with overall patient satisfaction. Injection pain versus satisfaction correlated with a spearman coefficient of -0.467 (p=0.0161), indicating less pain correlated with greater satisfaction. Post-injection pain and satisfaction correlated with a spearman coefficient of -0.350 (p=0.0794), indicating less post-injection pain also correlated with greater satisfaction.

Prior injection

Nine of 14 patients (64%) in group A and 7 of 12 (58%) in group B had at least one earlier corticosteroid injection (p=1.00). Prior exposure did not influence injection pain (median 3.0 vs 2.0; p=0.94) nor post-injection pain (median 3.0 vs 1.0; p=0.27). No significant interaction was observed between needle gauge and prior-injection status (p interaction=0.84).

Across this small pragmatic cohort, switching between an 18-gauge and a 22-gauge needle did not appreciably alter procedural pain, post-injection discomfort, or patient satisfaction.

Injector variability

Kruskal-Wallis test revealed no significant differences between individual injectors (H=0.88, p=0.97).

DISCUSSION

This study found no statistically significant difference in perceived pain and post-injection discomfort when completing IACIs for knee OA using 18 versus 22 gauge

needles. Recommended gauge size for knee and shoulder IA injections for OA pain relief varies across the literature.[22] Some studies have suggested that the ideal needle size should be a 22-gauge needle with a length between 1.5 and 3.5 inches.[23,24] While some prior evidence has indicated increased patient discomfort with larger gauge needles, we did not observe this association in our community, outpatient orthopedic setting.[22]

One possible factor to account for these findings is that injection-related anxiety and anticipation of pain is a difficult to measure, subjective assessment produced by the patient and is naturally variable. Our analysis revealed that pre-injection nervousness and anticipated pain had moderate positive correlation with both injection and post-injection pain. These findings underscore the overall narrative that needle gauge is not a primary determinant in patient pain. Whether psychosocial factors play a role or not is left to be determined by further research on this topic.

To preserve the interval validity of the present study, the authors standardized procedural variables, and as mentioned above blinded all patients to needle size and profile. Importantly, patient satisfaction was similar across both groups, reinforcing clinical acceptability of both needle sizes. These findings expand on the gauge size range suggested by Bae et al (indicating an acceptable intra-articular gauge range of 22-25), given the lack of statistically significant difference found between 18 and 22 gauge needles.

The pre-study power analysis was the primary factor of consideration in determining the final size of our cohort. If psychosocial factors are a greater contributor to patient perception of pain, a more focused analysis of this question should be pursued in future studies. A higher powered, larger population study would be necessary to elucidate subtle trends identified in the present study, such as how post-injection pain was lower in the 18 gauge group (median=1.5, IQR: [1.0-3.8]) versus the 22 gauge group (median=3.5, [1.0-5.2]) (p=0.21).

This study has several limitations. First, the authors' assumptions of a priori power analysis were not met. Power analysis was conducted assuming normally distributed data, but Shapiro-Wilk testing revealed that the data was largely non-normal. In addition, the standard deviations of collected measurements (Table 2) were greater than those assumed based on the study by Tubach et al.[17] These misalignments indicate that the present study is likely underpowered. Other limitations include blinding-only the patient was blinded to the needle gauge and not the injector, nor the data analysts in the present study. There was also potential confounding variability in administrating providers. Multiple providers gave injections with different levels of clinical experience, potentially resulting in systematic differences in both mechanical/technical and provider-patient interaction skills. Notably, injector-related analysis was included to quantify these confounding effects and revealed no significant difference between operators. This is similar to other findings in the literature that resident placed injections did not lead to appreciably different patient outcomes.[25] Lastly, the focus on the knee joint in isolation in the present study provides an opportunity for further research on needle gauge in joints like the hip and shoulder. The authors resolved to investigate the knee only because it is the most common joint associated with OA.

CONCLUSION

The findings of the present study indicate there is no difference in perceived pain for 18 vs. 22 gauge needle IACIs in the knee. More research is needed to further elucidate nuanced and multifactorial influences on pain and anxiety related to IACIs. With no clear statistically significant differences in either pain or overall patient experience observed by the authors, it is perhaps reasonable for providers to prioritize items like injectate viscosity profile, personal experience/provider preference, and supply availability when deciding on needle gauge. The key takeaway from this study is the potential value in addressing psychological factors on behalf of the patient before, during and after the injection-ensuring better rapport with the patient and higher levels of trust in the provider in an effort to minimize perceived pain. More work is needed with larger, multi-central trials to further elucidate the nuanced and multifactorial consequences of procedural variables in IACI therapy.

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