18350 PCT (AP)

KETOROLAC TROMETHAMINE COMPOSITIONS FOR TREATING OR PREVENTING OCULAR PAIN

By inventors
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Related Application

[001] This application claims the benefit of U.S. Provisional applications serial number 61/067,925, filed March 3, 2008; serial number 61/096,096 filed September 11, 2008; serial number 61/111,919 filed November 6, 2008, and U.S. Non-provisional application 12/396,131 filed March 2, 2009, the disclosures of which are hereby incorporated in their entirety herein by reference.

Field of the Invention

[002] This invention relates to pharmaceutical compositions. More particularly, this invention relates to topical ophthalmic solutions comprising 5-benzoyl-2,3-dihydro-1*H*-pyrrolizine-1-carboxylic acid, otherwise known as ketorolac, and the use of ketorolac for treating or preventing ocular pain .

Description of the Related Art

[003] Topical nonsteroidal anti-inflammatory drugs (NSAIDs) are used to control pain and postoperative inflammation. All drugs are associated with some adverse effects. With the use of NSAIDS in topical ophthalmic treatment of patients, surface toxicity has been a concern, and incidents of keratitis, corneal subepithelial infiltrates, ulceration, and corneal melts have been reported (Guidera et al, *Ophthalmology*, 2001, 108 (5), pp. 936-944; Solomon et al, *J Cataract Refract Surg*, 2001, 27 (8), pp. 1232-1237; Teal et al, *J Cataract Refract Surg*, 1995, 21(5) , pp. 516-518). Further, patients often report burning or stinging on instillation (Jaanus et al, Antiinflammatory Drugs. Clinical Ocular Pharmacology, Bartlet, J.D. and Jaanus, S.D., Ed., Boston: Heineman, 2001, pp. 265-298). The burning or stinging could be related to the concentration of the active component of the formulation.

[004] Ketorolac tromethamine 0.5% (w/v) ophthalmic solution, available from Allergan, Inc., under the tradeneme ACULAR®, is a safe and effective NSAID with proven analgesic and anti-inflammatory activity. The most common adverse event

associated with the use of the 0.5% ketorolac formulation is ocular irritation, primarily burning and stinging upon instillation. Keterolac tromethamine 0.4% (w/v) ophthalmic solution, under the tradename ACULAR LS ®, has shown improved bioavailability and less stinging on instillation than ACULAR®, but there remains a need for an improved keterolac tromethamine formulation with greater bioavailability and greater tolerability, minimized ocular surface toxicity, improved patient comfort, increased retention time of the active ingredient and improved wound healing capabilities during use.

[005] It is one object of this invention to provide a keterolac formulation for instillation in the eye to eliminate or reduce ocular irritation, to improve tolerability, compliance, duration and effect of keterolac, to allow for dosing from four times daily to twice daily, and to increase the effectiveness of treatment by being free of benzalkonium chloride or other preservatives.

[006] It is another object of the invention to improve bioavailability and increase the ocular absorption of ketorolac yet provide an aqueous solution having an optimized concentration of ketorolac.

[007] It is another object of the invention to extend the effects of keterolac and allow for a decrease in required daily dosage.

[008] It is another object of the invention to provide reduction of inflammation associated with cataract surgery and reduction of pain associated with cataract surgery in comparison to other keterolac formulations.

[009] It is another object of the invention to create a keterolac formulation with improved wound healing capabilities.

[0010] Other objects of this invention will become apparent from a reading of the present specification.

Summary

[0010a] In a first aspect, there is provided a topical aqueous ophthalmic solution comprising keterolac tromethamine, carboxymethyl cellulose and no preservative.

[0010b] In a second aspect, there is provided the use of the topical aqueous solution as defined above in the manufacture of a medicament for treatment of ocular pain associated with postoperative photorefractive keratectomy.

[0010c] In a third aspect, there is provided the use of the topical aqueous as defined above in the manufacture of a medicament for preventing ocular pain wherein the medicament may be administered before or after eye surgery.

[0010d] In a fourth aspect, there is provided the use of the topical aqueous solution as defined above in the manufacture of a medicament for increasing healing time of the eye after surgery in comparison to keterolac solutions containing a preservative.

[0011] The present disclosure provides an aqueous ophthalmic formulation comprising an effective amount of ketorolac but having an optimized concentration of keterolac in

comparison other commercially available keterolac products. The aqueous ophthalmic soloution of the present disclosure comprises carboxymethyl cellulose, e.g. sodium carboxymethyl cellulose, having a pH within the range of from about 6.8 to 7.4, which is comfortable when topically applied to the eye of a patient, wherein the concentration of carboxymethyl cellulose and, preferably, the pH, is selected to provide an increased absorption of ketorolac in the eye of a patient as compared to a comparative keterolac solution that differs only in not including the carboxymethyl cellulose. That is, the absorption of keterolac may be 130% or greater than the absorption of a comparative aqueous ketorolac ophthalmic solution having the same or higher concentration of ketorolac.

[0012] More preferably, the aqueous ophthalmic solution of this disclosure has a pH within the range of from 6.8 to 7.4, particularly 6.8.

[0013] More preferably, the aqueous ophthalmic solution of the present disclosure has a concentration of carboxymethyl cellulose of from about 0.2 to about 2 percent, by weight, even more preferably from about 0.5 to 1.5 percent, by weight, and most preferably about 0.5% w/v.

[0014] Even more preferably, the aqueous ophthalmic solution of the present disclosure comprises a mixture of medium viscosity and high viscosity sodium carboxymethyl cellulose.

[0015] More preferably, the aqueous ophthalmic solution of the disclosure comprises an effective amount of ketorolac of from .25 to .50 percent, by weight, or about 0.45 percent, by weight.

[0016] More preferably, the aqueous ophthalmic solution of the disclosure has a viscosity of from 5 to 50 cps, preferably from 10 to 30 cps.

[0017] It has been surprisingly discovered that optimizing the concentration of ketorolac tromethamine reduces the occurrence of adverse events while maintaining clinical efficacy. Additionally, it has been discovered that the optimized concentration of ketorolac tromethamine in combination with carboxymethyl cellulose offers surprising and clear benefits in terms of formulation in that no preservative, chelating

agent, and surfactant are required for formulation. Thus, finding a way to increase the absorption of ketorolac benefits the patient who can use a solution having an optimized concentration of ketorolac and obtain similar results in terms of efficiency as compared to a ketorolac solution having a higher concentration of ketorolac.

[0018] Thus, this disclosure relates to an aqueous topical ophthalmic composition comprising 0.25 to .50 percent by weight, more preferably from 0.35% to 0.45% by weight and most preferably about 0.45 % ketorolac tromethamine by weight/volume. The present disclosure also contains from 0.2 to 2 percent by weight, more preferably from 0.5 to 1.5 percent by weight and most preferably about 0.5 % w/v percent of medium and high molecular weight sodium carboxymethyl cellulose. Another aspect of this disclosure relates to a method of treating or preventing ocular pain in a person comprising topically administering to said patient a sterile composition comprising from .25 to .50 percent, by weight, more particularly from 0.35% to 0.45% by weight, or about 0.45% w/v ketorolac tromethamine in combination with from 0.2 to 2 percent, by weight, preferably from 0.5 to 1.5 percent by weight, and most preferably 0.5% percent by weight/volume, sodium carboxymethyl cellulose and mixtures thereof.

[0019] While not intending to limit the scope of this disclosure in any way, of particular interest in relationship to this invention is the use of aqueous topical ophthalmic compositions of 0.45% (w/v) ketorolac tromethamine for the treatment of ocular pain, especially for the treatment of ocular pain in postoperative photorefractive keratectomy (PRK) surgery patients which improves healing. It is surprising that the lower concentration of ketorolac as compared to the Acular® product, discussed herein, would reduce the incidence of adverse events and enhance comfort while maintaining clinical efficacy. Two drops (0.1 mL) of 0.5% ketorolac tromethamine ophthalmic solution instilled into the eyes of patients 12 hours and 1 hour prior to cataract extraction achieved measurable levels in 8 of 9 patients' eyes (mean ketorolac concentration 95 ng/mL aqueous humor, range 40 to 170 ng/mL). Ocular administration of ketorolac tromethamine reduces prostaglandin E_2 (PGE_2) levels in aqueous humor. The mean concentration of PGE_2 was 80 pg/mL in the aqueous humor of eyes receiving vehicle and 28 pg/mL in the eyes receiving 0.5% ketorolac tromethamine ophthalmic solution.

[0020] Ocular administration of 0.45% w/v ketorolac tromethamine ophthalmic solution increases relative bioavailability of ketorolac in the aqueous humor of rabbits to greater than 200% and in the iris-ciliary body to nearly 300%, compared with 0.5% ketorolac tromethamine ophthalmic solution. This enhanced ketorolac bioavailability allows for a reduction in dosing frequency from QID with 0.5% ketorolac tromethamine ophthalmic solution to BID with 0.45% keterolac solution. Preclinical data indicate systemic ketorolac exposure levels achieved following ocular administration of 0.45% keterolac solution are comparable to levels achieved with 0.5% ketorolac tromethamine ophthalmic solution.

Detailed Description of the Invention

[0021] During the reformulation of Allergan's marketed Acular LS® product (0.40 % w/v keterolac), it was surprisingly found that a test formulation containing 0.45% ketorolac tromethamine and sodium carboxymethylcellulose (NaCMC) exhibited significantly better ocular absorption in rabbits than did the currently marketed product, i.e. Acular LS®.

[0022] Since the viscosities of the two test solutions were virtually identical, the mechanism for achieving increased ocular penetration compared to the control formulation cannot be accounted for only by the viscosity of the test solutions. In fact, a comparison of two identical carboxymethyl cellulose–containing solutions which differ only in having viscosity of 11 and 22 cps shows similar absorption of ketorolac into the aqueous humor. While not wishing to be bound by theory, it is believed that there is a functional relationship between the sodium carboxymethyl cellulose and either,the ketorolac or some component of the ocular surface that facilitates absorption of ketorolac.

[0023] All of the aqueous topical ophthalmic solutions of this invention are contemplated for use in treating or preventing ocular pain. Preferably, all of the solutions of this invention are contemplated for use when said ocular pain is a result of photorefractive keratectomy surgery (PRK).

[0024] One important aspect of this invention is that the solutions of the present invention have a concentration of ketorolac tromethamine which is optimized to reduce

side effects, while maintaining clinical efficacy in treating ocular pain. As such, the concentration of ketorolac tromethamine in compositions related to this invention is preferably from 0.35% to 0.45%, most preferably the concentration of ketorolac tromethamine in the aqueous topical ophthalmic solution of this invention is 0.45% ketorolac tromethamine, by weight.

[0025] Carboxymethyl cellulose (CMC) is a carboxymethyl derivative of cellulose formed by the reaction of cellulose with alkali and chloroacetic acid. As a result of said reaction, carboxymethyl groups are bound to some of the hydroxyl groups of the glucopyranose units that make up the backbone of cellulose. The degree of substitution of carboxymethyl varies from about 0.6 to 0.95 per glucopyranose unit. CMC is used in aqueous solutions usually as the sodium salt to increase viscosity.

[0026] Carboxymethyl cellulose is available in various molecular weights. Low molecular weight carboxymethyl cellulose has a Mw of about 90,000 and a 2% solution thereof will have a viscosity of about 1.1 cP at 25° C. Medium weight carboxymethyl cellulose has a Mw of about 250,000. High molecular weight carboxymethylcellulose has a Mw of about 700,000 and a 2% solution will have a viscosity of about 12 cP at 25° C.

[0027] For the purpose of the present invention, it is desirable to use a mixture of medium and high molecular weight sodium carboxymethyl cellulose. For example, from 25/75 to 75/25 carboxymethyl cellulose, preferably from 30/70 to 70/30 and most preferably about 35/65 medium/high molecular weight sodium carboxymethyl cellulose.

[0028] The fact that the concentration of ketorolac tromethamine in compositions related to this invention achieves greater or equal absorption of ketorolac into the aqueous humor of the eye and includes carboxymethyl cellulose, allows the solutions of the present invention to be prepared with no preservative, surfactant and chelating agent. This is a significant advantage over prior art keterolac formulations as preservatives, surfactants and chelating agents can cause irritation to the eye resulting in less patient compliance and less effectiveness of prior art keterolac formulations.

[0029] The term preservative has the meaning commonly understood in the ophthalmic art. Preservatives are used to prevent bacterial contamination in multiple-use ophthalmic preparations, and, while not intending to be limiting, examples include benzalkonium chloride, stabilized oxychloro complexes (otherwise known as Purite®), phenylmercuric acetate, chlorobutanol, benzyl alcohol, parabens, and thimerosal. Preferably, the keterolac solution of the present invention is preservative free.

[0030] The term surfactant used in this invention has the meaning commonly understood in the art. Surfactants are used to help solubilize the therapeutically active agent or other insoluble components of the composition. Anionic, cationic, amphoteric, zwitterionic, and nonionic surfactants may all be used in this invention. If a surfactant is included in the solutions of this invention, preferably, a nonionic surfactant is used. While not intending to limit the scope of the invention, some examples of useful nonionic surfactants are polysorbates, poloxamers, alcohol ethoxylates, ethylene glycol-propylene glycol block copolymers, fatty acid amides, and alkylphenol ethoxylates, and phospholipids. Most preferably, the surfactant is an octylphenol ethoxylate with an average of 40 ethoxylate groups. This type of surfactant, also known as octoxynol-40 or Igepal CA-897®, can be purchased under the Igepal CA-897® tradename from Rhône-Poulenc. Preferably, the keterolac solution of the present invention is surfactant free.

[0031] The term chelating agent refers to a compound that is capable of complexing a metal, as understood by those of ordinary skill in the chemical art. Chelating agents are used in ophthalmic compositions to enhance preservative effectiveness. While not intending to be limiting, some useful chelating agents for the purposes of this invention are edetate salts like edetate disodium, edetate calcium disodium, edetate sodium, edetate trisodium, and edetate dipotassium. Preferably, the keterolac solution of the present invention is chelator free.

[0032] In addition to surfactants, preservatives, and chelating agents, tonicity agents and other excipients are often used in ophthalmic compositions. Tonicity agents are often used in ophthalmic compositions to adjust the concentration of dissolved material to the desired isotonic range. Tonicity agents are known to those skilled in the

ophthalmic art, and, while not intending to be limiting, some examples include glycerin, mannitol, sorbitol, sodium chloride, and other electrolytes. Preferably, the tonicity agent is sodium chloride.

[0033] One preferred embodiment of this invention relates to an aqueous topical ophthalmic composition comprising 0.4% ketorolac tromethamine, from 0.2 to 2.0 %, by weight, sodium carboxymethyl cellulose.

[0034] The most preferred embodiment of this invention relates to an aqueous topical ophthalmic composition consisting of 0.45% (w/v) of ketorolac tromethamine, 0.5 % w/v of carboxymethylcellulose sodium, e.g. a mixture of medium and high viscosity sodium carboxymethyl cellulose, sodium chloride, sodium citrate dehydrate, sodium hydroxide, hydrochloric acid and purified water.

Example 1

[0035] Unless otherwise specified, all steps in this procedure were carried out at room temperature. The following procedure was followed in accordance with the amounts listed in Table 1 below. Purified water was charged into the main batch vessel. Mixing was initiated to produce a vortex sufficient to disperse and/or dissolve all product ingredients without excessive aeration or foam formation. The following components were added directly into the vortex in order, allowing each to dissolve before adding the next: sodium chloride, calcium chloride, dihydrate magnesium chloride, hexahydrate, boric acid, sodium borate, sodium carboxymethyl cellulose as a an percent aqueous solution comprising including a mixture of 65% medium molecular weight and 35% high molecular weight carboxymethyl cellulose. The solution was mixed for no longer than 15 minutes. A specified amount of 1N sodium hydroxide, was then added. The pH was checked and, if needed, was adjusted to 7.3 with 1N sodium hydroxide or 1N hydrochloric acid. Ketorolac tromethamine was then added based on "as is" assay and mixed until completely dissolved based on visual inspection. When dissolved, the solution pH was again checked and if needed adjusted to pH 7.3 - 7.5 (final target pH is 7.4) with 1N sodium hydroxide or 1N hydrochloric acid. Purified water was then added to bring the bulk solution to final volume and allowed to mix for at least 15 minutes to ensure uniformity. The solution was then sterile filtered for use.

[0036]

Table 1. 0.4% Ketorolac Tromethamine Ophthalmic Solution of the Invention

Keterolac Tromethamine	0.4%
CMC, Med Visc.	.65%
CMC Low Visc.	.35%
Potassium chloride	0.14%
Calcium chloride, dihydrate	0.060%
Magnesium chloride, hexahydrate	0.060%
Boric acid	.060%
Sodium borate	.1225%

Example 2

[0037] Unless otherwise specified, all steps in this procedure were carried out at room temperature. The following procedure was followed in accordance with the amounts listed in Table 2 below. Purified water at 90% of batch size was charged into the main batch vessel. Mixing was initiated to produce a vortex sufficient to disperse and/or dissolve all product ingredients without excessive aeration or foam formation. The following components were added directly into the vortex in order, allowing each to dissolve before adding the next: sodium chloride, edetate disodium, octoxynol-40 (as a 70% stock solution) and benzalkonium chloride (as a 10 % stock solution). The amount of benzalkonium chloride added took into account the assay of the stock solution used. The solution was mixed for no longer than 15 minutes. A specified amount of 1N sodium hydroxide, 1.85 mL per liter of final bulk product, was then added. The pH was checked and if needed was adjusted to 10.7 - 11.0 with 1N sodium hydroxide or 1N hydrochloric acid. Ketorolac tromethamine was then added based on "as is" assay and mixed until completely dissolved based on visual inspection. When dissolved, the solution pH was again checked and if needed adjusted to pH 7.3 - 7.5 (final target pH is 7.4) with 1N sodium hydroxide or 1N hydrochloric acid. Purified water was then added to bring the bulk solution to final volume and allowed to mix for at least 15 minutes to ensure uniformity. The solution was then sterile filtered for use.

[0038]

Table 2. 0.4% Ketorolac Tromethamine Ophthalmic Solution (Comparative)

Ketorolac Tromethamine	0.4%
Edetate Disodium	0.015%
NaCl	0.79%
Benzalkonium Chloride	0.006%
Octoxynol-40	0.003%
Ph	7.4

Example 3

[0039] This example was prepared according to the procedure of Example 1, except that hydroxypropyl cellulose was used in place of the sodium carboxymethyl cellulose in an amount sufficient to provide a viscosity equivalent to the viscosity of the composition of Example 1.

Example 4

[0040] The following composition was manufactured on a volume basis at ambient temperates from two principal parts. Each part is manufactured separately and then combined under controlled sequences to form a sterile bulk product: the first part (Part 1) involves the dissolution of carboxymethylcellulose sodium in water followed by bulk heat sterilization, and the second part (Part 2) involves dissolution of keterolac tromethamine and salts in water sterile filtration throng a 0.2 micron membrane into a sterile pressure vessel. The sterile bulk solution is then clarity filtered through a 20 micron polypropylene membrane filter into the filling machine reservoir.

[0041] The sterile post-clarity filtered solution is then filled by a UD filling machine via blow-fill-seal process into UD vials using virgin LDPE resin without colorant. The filling is done in an ISO Class 5 environment. The nominal fill is 0.4 mL into 0.9 mL capacity vials.

[0042]

Table 3: 0.45 % w/v Keterolac Tromethamine Ophthalmic Solution

Ingredient	**Function**	**Concentration (% w/v)**
Keterolac tromethamine	Active	0.45%
Carboxymethycellulose Sodium (Med. Viscosity)	Thickening Agent	0.325%
Carboxymethycellulose Sodium (High Viscosity)	Thickening Agent	0.175%
NaCl	Tonicity Agent	0.7%
Sodium Citrate	Buffer	0.2%

Dihydrate		
Sodium Hydroxide (1N)	pH adjustment	Adjust to pH 6.8
Hydrochloric Acid (1N)	pH adjustment	Adjust to pH 6.8
Purified Water	Vehicle	Q.S.

Example 5

[0043] Comparison of Aqueous Humor Ketorolac Pharmacokinetics Following a Single Ocular Instillation of 0.45% Ketorolac Tromethamine Formulations with Varying pH to Acular LS® in New Zealand White Rabbits.

[0044] Study Objectives:

1) To compare aqueous humor ketorolac pharmacokinetics following a single ocular instillation of 0.45% ketorolac tromethamine formulations with varying pH and Acular LS® to New Zealand White rabbits;

2) This Example was designed to determine whether decreasing the pH of the composition would increase the absorption of ketorolac into the eye; and,

3) In addition, one arm of this trial was designed to test the effect of decreasing viscosity of the composition from 22 cps to 11 cps.

[0045] The specifics of this study are as follows:

Rabbit Aqueous Humor Ketorolac Concentrations following Administration of Three 0.45% Ketorolac Tromethamine Formulations and Acular LS

[0046]

Table 4

Treatment Groups	0.45% Ketorolac Tromethamine 22 cps pH=7.4
	0.45% Ketorolac Tromethamine 22 cps pH=7.2
	0.45% Ketorolac Tromethamine 22 cps pH=7.0
	0.45% Ketorolac Tromethamine 11 cps pH=7.0
	0.45% Ketorolac Tromethamine 22 cps pH=6.8

Acular LS pH=7.4

Dosing Route:	Topical ocular
Animal Gender:	NZW Rabbits/Female
Dosing Regimen	Single dose, bilateral
Timepoints:	1, 2 and 4 hrs post-dose
# Rabbits:	3 rabbits/timepoint +1 rabbit blank
	Total = 39 rabbits
Tissues/Matrices:	Aqueous Humor
Bioanalysis:	LC-MS/MS
Data analysis:	AUC_{0-t}, C_{max}

[0047] The results of the study are reported in Table 5, below.

Table 5

PK Parameters

Formulation	AUC_{0-4}± SE (ng·h/ml)	C_{max}± SD (ng/ml)	Relative %F*
0.45% CMC 22 cps pH 7.4 w.o "outlier"	627±51	265±71	135
045% CMC 22 cps pH 7.4	713±96	322±153	153
045% CMC 22 cps pH 7.2	620±50	240±84	133
045% CMC 22 cps pH 7.0	658±73	268±125	142
045% CMC 22 cps pH 6.8	939±163	389±258	202
045% CMC 11 cps pH 7.0	649±74	347±218	139
Acular LS®	465±65	211±106	100

Summary of the results:

[0048] The sodium carboxymethyl cellulose-containing formulations perform better than Acular LS® with a relative bioavailability ranging from 133% (0.45% Keto 22 cps pH 7.2) to 202% (0.45% Keto 22 cps pH 6.8). However, there is not a clear pH effect-because the 0.45% Keto 22 cps pH 7.4 has a relative bioavailability of 153%, although one anomalous result maybe driving this observation. Nevertheless, the solution having a pH of 6.8 shows the best bioavailability.

Example 6

[0049] A multicenter, randomized, double-masked, parallel-group study is carried out using the 0.4% ketorolac tromethamine formulations of Examples 2 and 3. The study subjects consisted of 157 patients (78-79/group) undergoing unilateral PRK surgery. The key inclusion criteria for the study is that each subject a) is a candidate for unilateral photorefractive keratectomy surgery (PRK) within 7 days after the initial visit, b) have best-corrected ETDRS visual acuity of 20/100 or better, and c) is capable of wearing a soft bandage contact lens. Key exclusion criteria are a history of refractive ocular surgery and sensitivity to study medication or its vehicle, Tylenol #3®, or Ocuflox®. The patient demographics are shown in Table 6. A total of 157 patients are enrolled with an age range of 20–66 years. There are no significant demographic differences between treatment groups.

[0050]

Table 6: Patient Demographics

	n	%
Gender		
Female	91	58
Male	66	42
Age, mean ± SD	39 ± 10	
Race		
Caucasian	148	94
Black	5	3
Hispanic	2	1
Asian	1	1
Other	1	1

[0051] Each subject receives the Ocuflox® 5 min prior to study medication. The study subjects then receive ketorolac tromethamine 0.4% ophthalmic solution of Example 2 or Example 3, 1 drop QID for up to 4 days. Then all subjects are then instructed to take Tylenol #3® as needed for intolerable pain (escape medication). Patients use electronic

diaries with date and time stamp to record the ocular pain they experience as one of the following: no pain, mild, moderate, severe, intolerable.

[0052] The pain intensity is less for the subjects who receive the solution of Example 2 during the first 12 hours post-PRK compared to those who receive the solution of Example 3. In particular, during the first 12 hours post-PRK, the group that receive the solution of Example 2 had fewer patients with severe or intolerable pain compared with the receive the solution of Example 3. In particular, the median pain intensity reported by the group which receive the solution of Example 2 was 1 grade less than with the group which receive the solution of Example 3 (moderate vs. severe on a 5-point scale of 0 = no pain to 4 = intolerable pain). Additionally, pain intensity is also less for the group which receive compared with the group which receive the solution of Example 3.

[0053] This clinical study shows that the solution of invention provides a greater degree of absorption of ketorolac as compared to the solution without sodium carboxymethylcellulose despite the fact that the solutions have the same concentration of ketorolac and are at the same viscosity.

[0054] In summary, the 0.4% ketorolac formulation is clinically effective in treating post PRK ocular pain. In patients treated with 0.4 ketorolac tromethamine-the patients treated with the solution comprising sodium carboxymethyl cellulose experienced significantly greater and faster pain relief, and used less escape medication compared to the patients treated with the solution comprising hydroxypropylcellulose.

Example 7

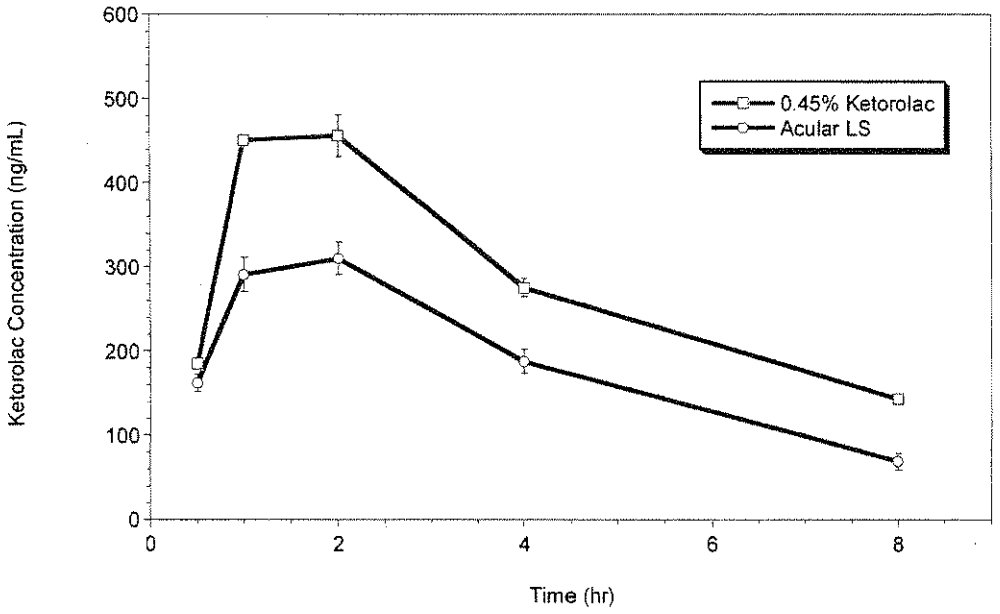
[0055] Rabbit Ocular Pharmacokinetic Evaluation of Keterolac Tromethamine 0.45%

NZW Rabbits/Female

Dosing Regimen:	Single ocular dose, bilateral
Timepoints:	0.5, 1, 2, 4, 8, 10 and 24 hrs post-dose
Tissues/Matrices:	Aqueous Humor and Iris-ciliary body
Bioanalysis:	LC-MS/MS
Data Analysis:	Pharmacokinetic analyses and simulation

[0056]

Table 7: Ocular Pharmacokinetics, Aqueous Humor: Increased and Prolonged Keterolac Exposure



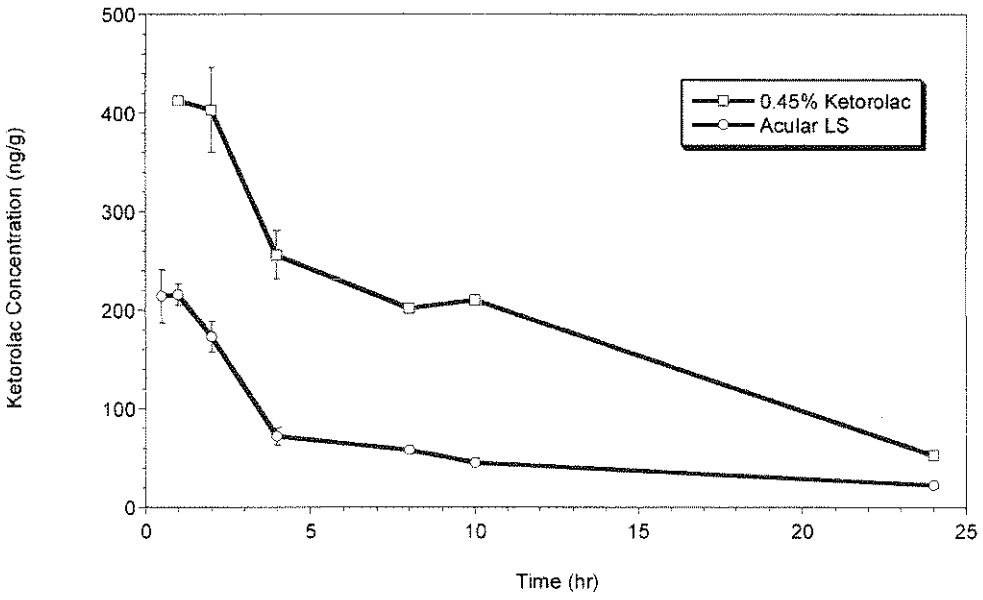
[0057]

Table 8: Ocular Pharmacokinetics, Aqueous Humor Relative bioavailability based on AUC0-t comparison to Acular LS®

	0.45% Ketorolac	Acular LS®
Cmax (ng/mL)	456	310
AUC0-t (ng·h/mL)	2230	1467
%Relative Bioavailability	178	100

[0058]

Table 9: Ocular pharmacokinetics in Iris-ciliary body



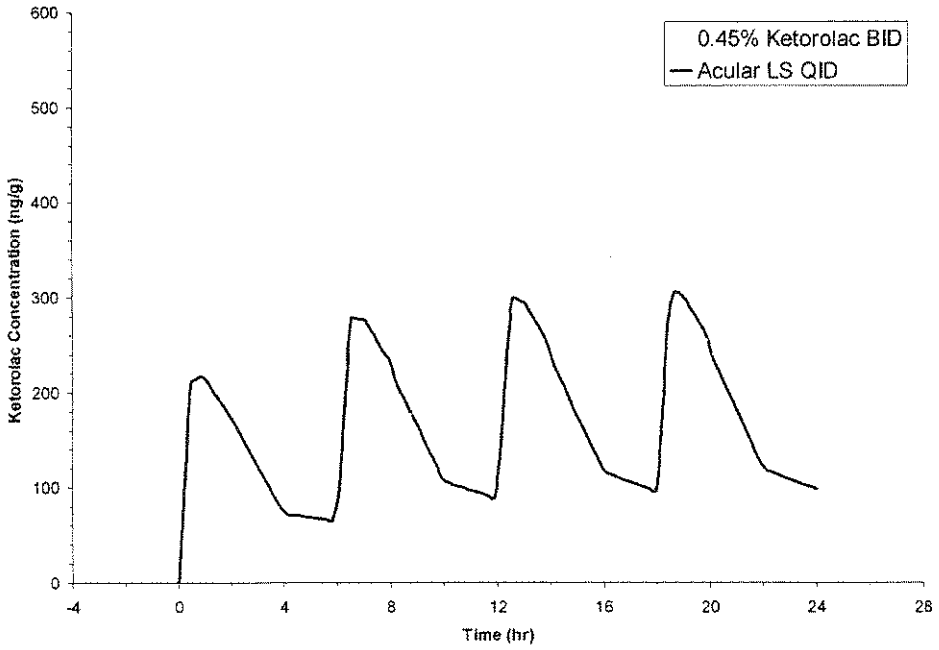
[0059]

Table 10: Ocular Pharmacokinetics: Iris Ciliary Body, Relative bioavailability based on dose normalized AUC comparison to Acular LS®, Increased and Prolonged Keterolac Exposure

	0.45% Ketorolac	Acular LS®
Cmax (ng/g)	429	216
AUC0-∞ (ng·h/g)	5090	1860
%Relative Bioavailability	285	100

[0060]

Table 11: Multiple Dose Simulation: Iris-Ciliary Body 0.45% Ketorolac BID vs. Acular LS® QID



	0.45% Ketorolac BID	Acular LS ® QID
AUC0-τ (ng·hr/g)	2910	725

[0061]

Conclusions:

1) Increase in relative bioavailability of keterolac as compared to Acular LS®;

2) Increased ketorolac concentrations are maintained longer post-dose; and

3) Together these data support a reduction in dosing frequency from 4X/day to 2X/day.

[0062]

Table 12: Safety and Tolerability Results

Variable	**Ketorolac 0.45%**	**ACULAR LS 0.40%**
Ocular AEs-Irritation	**10.0% (2/20)**	**15.4% (6/39)**
Symptoms-Burning/stinging (≥ 1 grade increase)	**10.0% (2/20)**	**12.8% (5/39)**
Bulbar hyperemia (≥ trace)	**10.0% (2/20)**	**23.1% (9/39)**
Ocular comfort (≥ comfortable)	**90-100%**	**84-100%**

[0063]

Conclusion:

Acular 0.45% is safe and well-tolerated when given 5 times over a half-day and compares very favorably to ACULAR LS.

The present invention is not to be limited in scope by the exemplified embodiments, which are only intended as illustrations of specific aspects of the invention. Various

modifications of the invention, in addition to those disclosed herein, will be apparent to those skilled in the art by a careful reading of the specification, including the claims, as originally filed. It is intended that all such modifications will fall within the scope of the appended claims.

What is claimed is:

1. A topical aqueous ophthalmic solution comprising keterolac tromethamine, carboxymethyl cellulose and no preservative.

2. The topical aqueous ophthalmic solution of claim 1 wherein the keterolac tromethamine is present in a concentration of approximately 0.40 - 0.45 percent by weight/volume.

3. The topical aqueous ophthalmic solution of claim 1 wherein the carboxymethyl cellulose is a combination of medium and high viscosity carboxymethyl cellulose.

4. The topical aqueous ophthalmic solution of claim 1 wherein the keterolac tromethamine is present in a concentration of 0.45 percent by weight/volume.

5. The topical aqueous ophthalmic solution of claim 4 having a pH between 6.8 and 7.4.

6. The topical aqueous ophthalmic solution of claim 5 wherein the concentration of carboxymethylcellulose is from 0.2 to 2 percent by weight.

7. The topical aqueous ophthalmic solution of claim 5 having a pH of approximately 6.8.

8. The topical aqueous solution of claim 4 wherein the solution is surfactant and chelator free. .

9. Use of the topical aqueous solution of claim 8 in the manufacture of a medicament for treatment of ocular pain associated with postoperative photorefractive keratectomy.

10. The topical aqueous solution of claim 4 further comprising a mixture of medium and high molecular weight sodium carboxymethyl cellulose.

11. The topical aqueous solution of claim 4 further comprising a mixture of medium and high viscosity sodium carboxymethyl cellulose, sodium chloride, sodium citrate dehydrate, sodium hydroxide, hydrochloric acid and purified water.

12. The topical aqueous solution of claim 10 wherein the combination of carboxymethyl cellulose and keterolac increases the absorption in the eye of a patient more than a solution of keterolac alone.

13. The topical aqueous solution of claim 1 wherein the keterolac tromethamine is present as a racemic mixture of R-(+) and S-(-)- ketorolac tromethamine.

14. The topical aqueous solution of claim 1 wherein the keterolac tromethamine is present in a mixture of crystal forms.

15. The topical aqueous solution of claim 5 wherein the viscosity is from 10 to 30 cps.

16. The topical aqueous solution of claim 6 wherein the carboxymethylcellulose is present in the amount of 0.5% percent by weight.

17. Use of the topical solution of claim 4 in the manufacture of a medicament for preventing ocular pain wherein the medicament may be administered before or after eye surgery.

18. Use of the topical aqueous solution of claim 4 in the manufacture of a medicament for increasing healing time for the eye after surgery in comparison to keterolac solutions containing a preservative.

19. The topical aqueous solution of claim 4 wherein the topical aqueous solution is instilled twice daily to achieve proper efficacy.

20. The topical aqueous solution of claim 4 wherein the aqueous solution is surfactant free.